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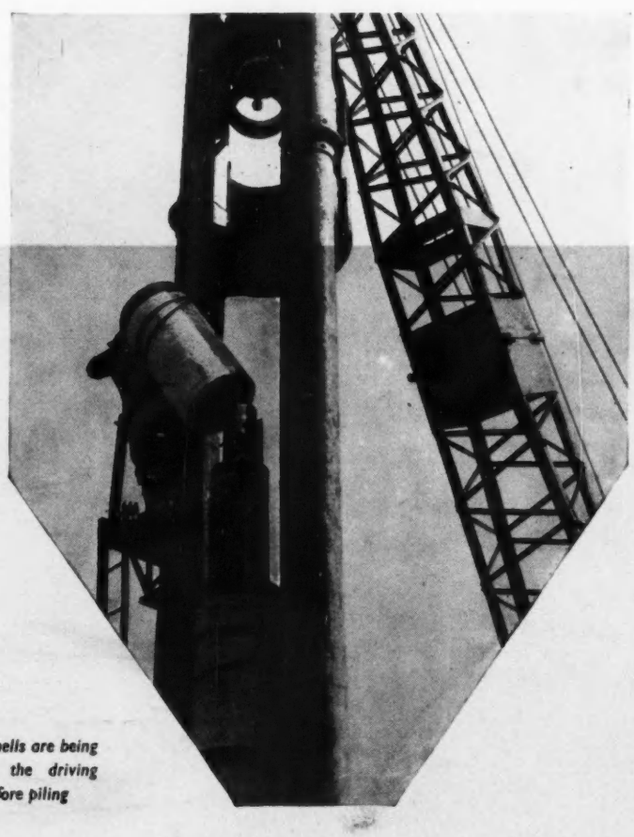

Here tubular shells are being assembled on the driving mandrel before piling

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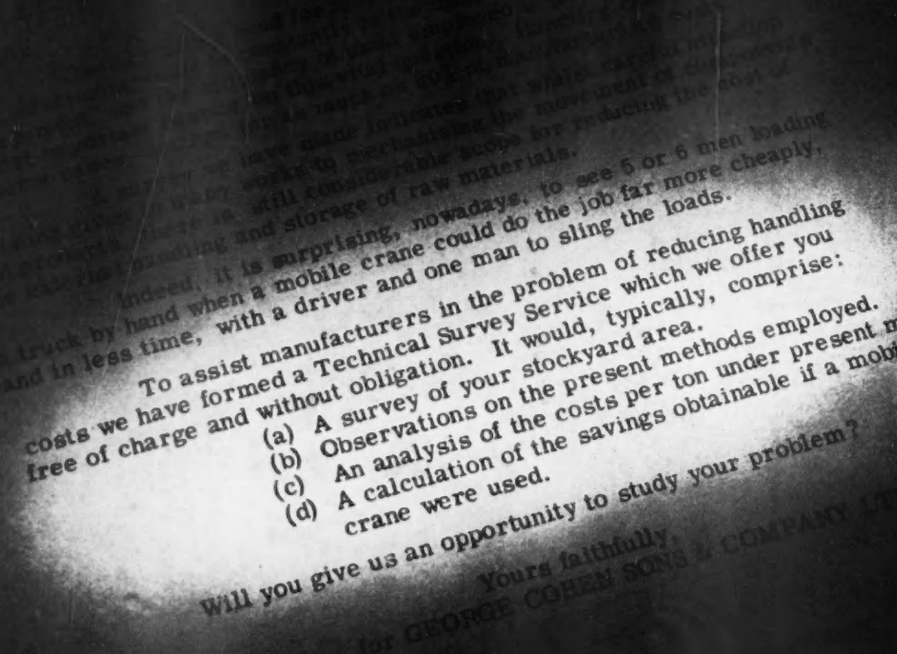
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No. 5337 **MAY 9, 1958** VOL. 205

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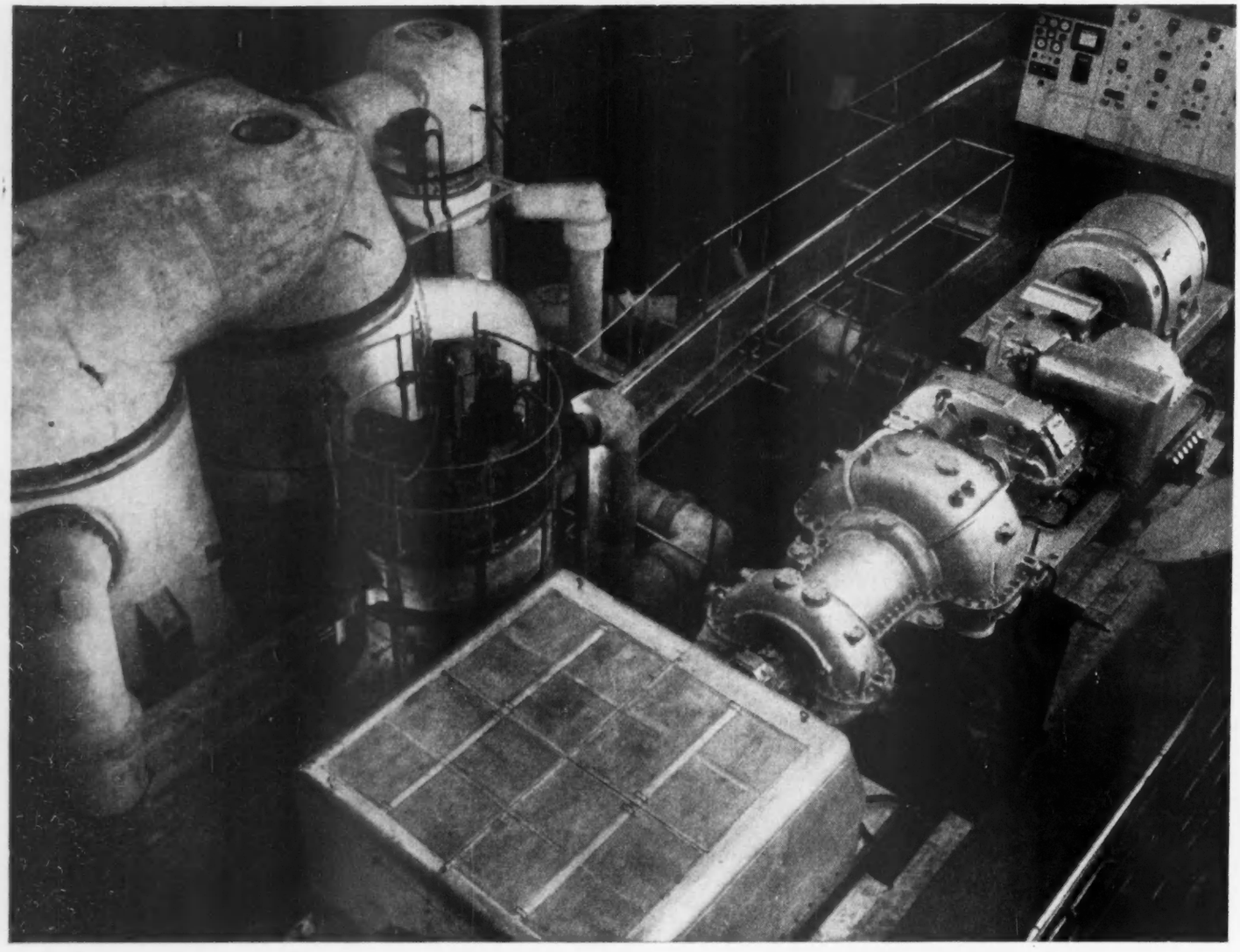

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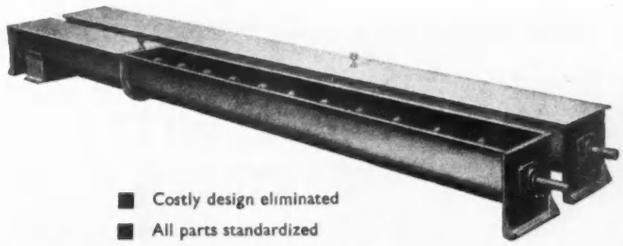

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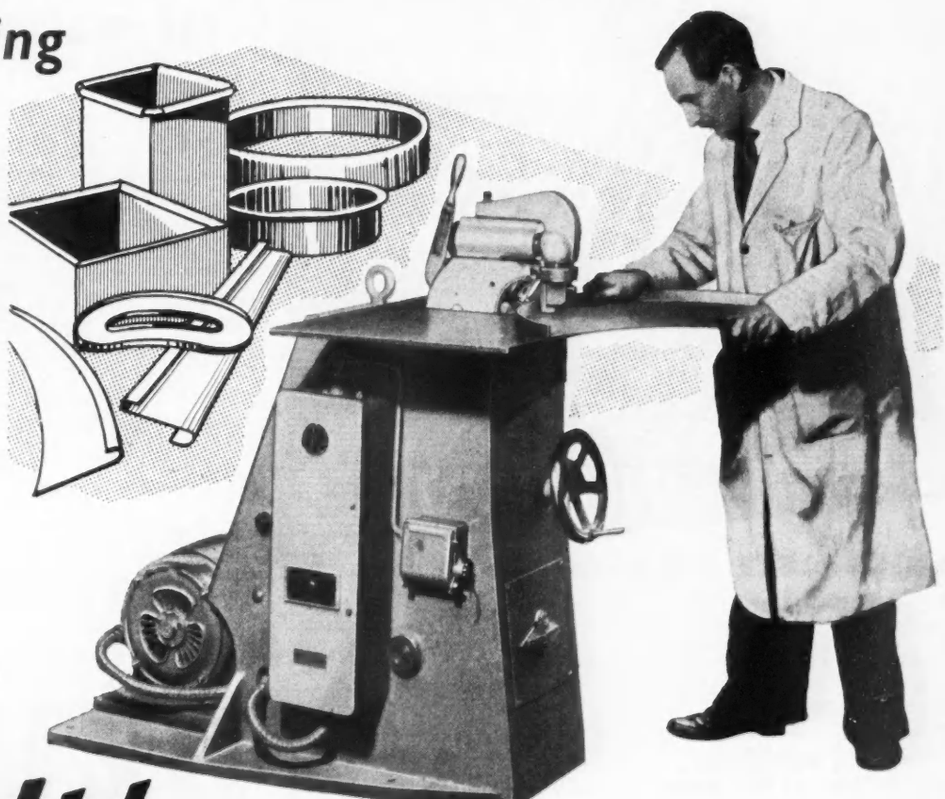

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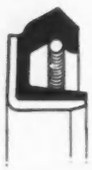

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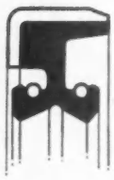

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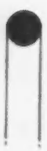

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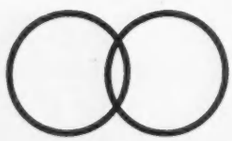

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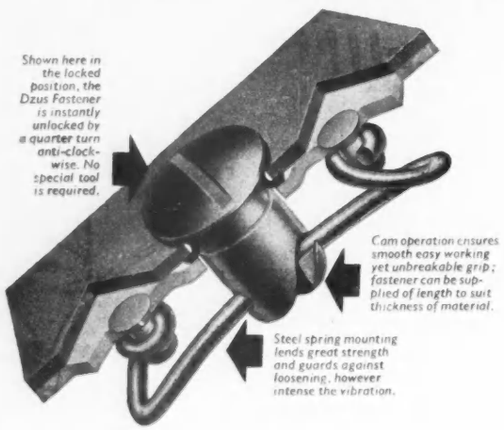
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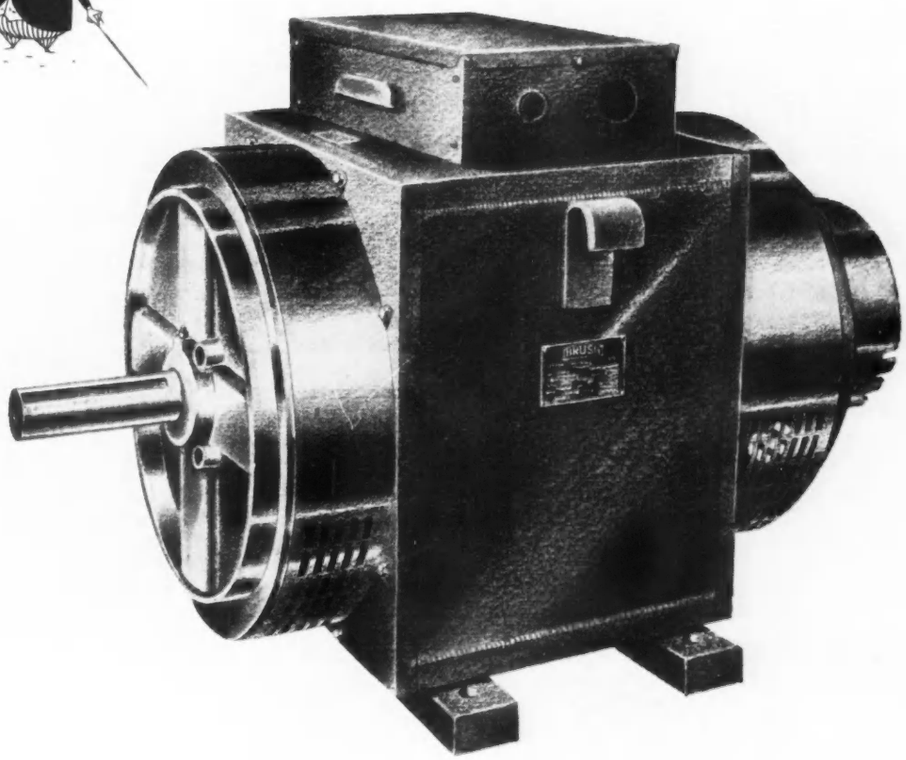

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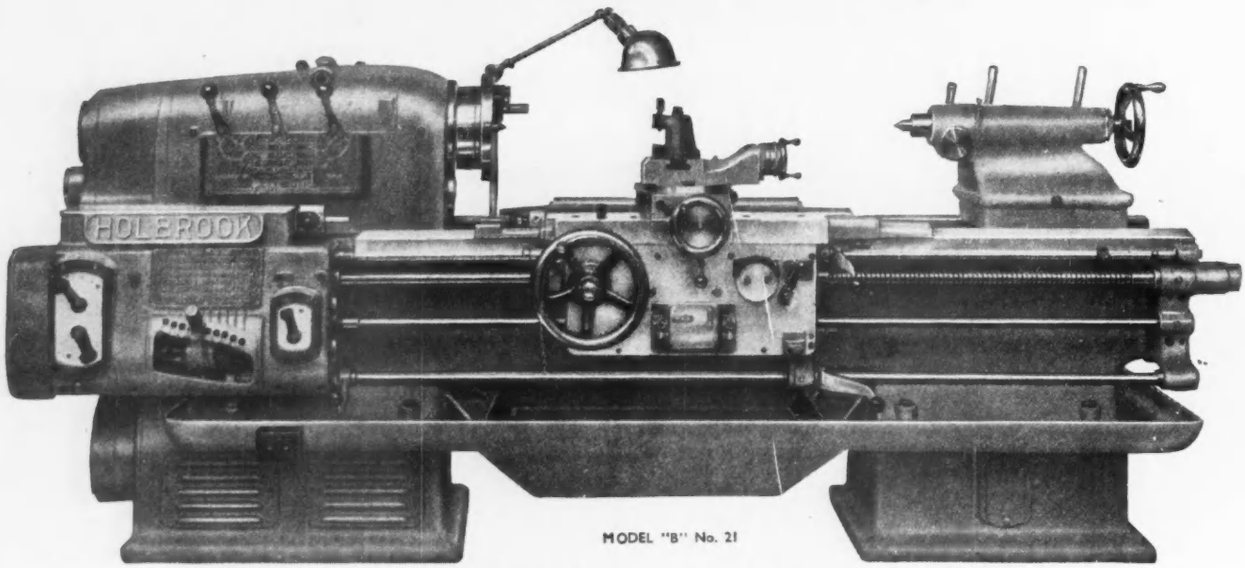

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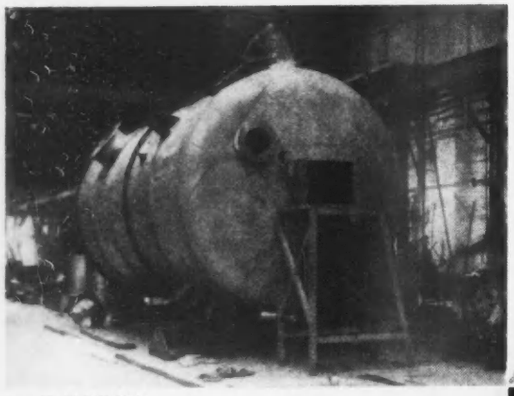

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Top right: A Solvent Storage Tank, Vacuum Receiver, Storage Tank and Buffer Tank.
Below: A Reactor Column.

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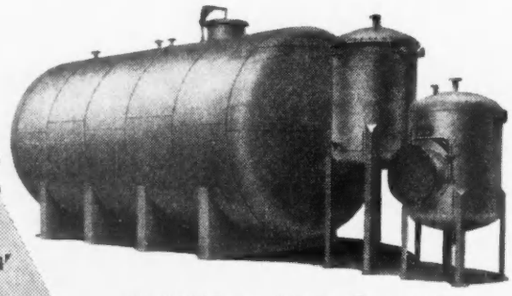

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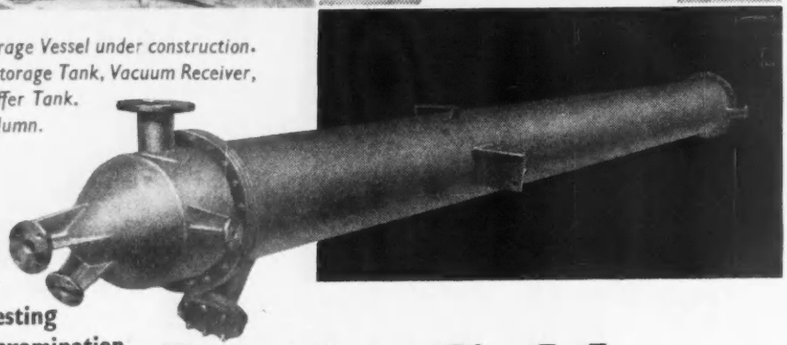

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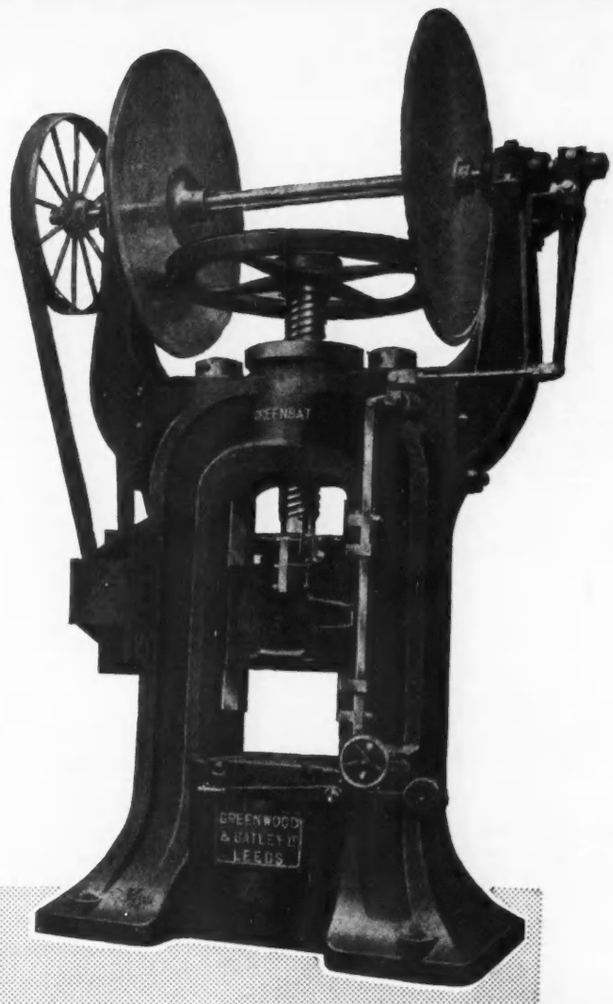

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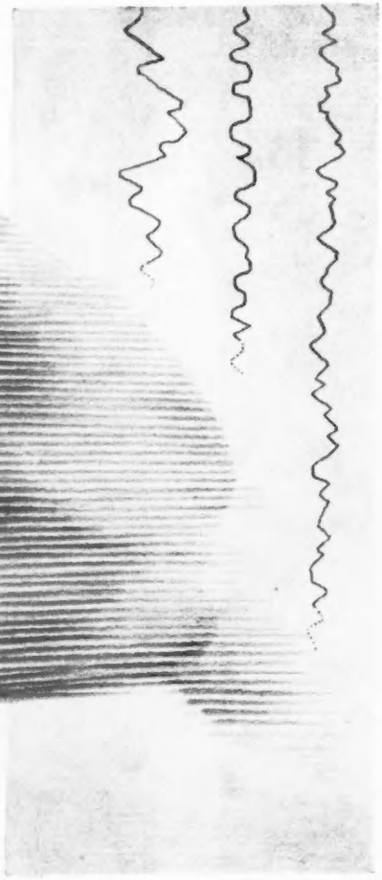

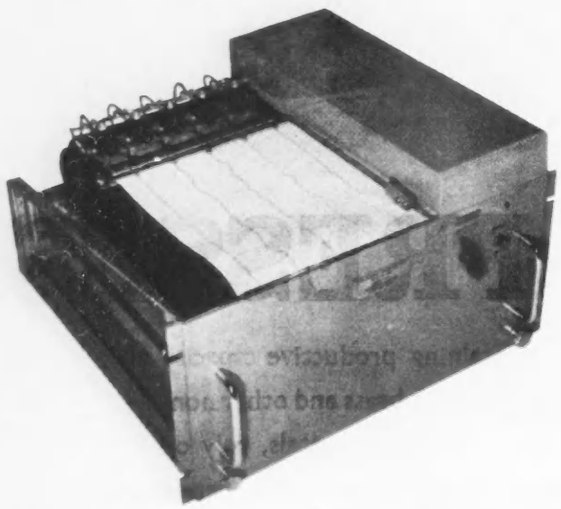

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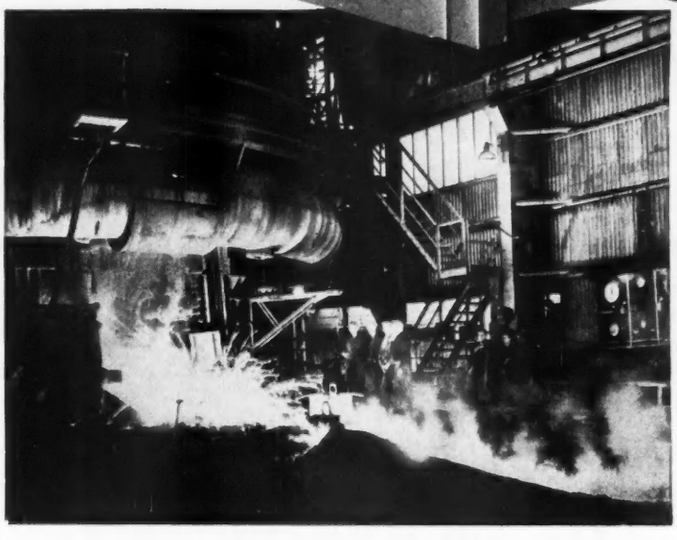

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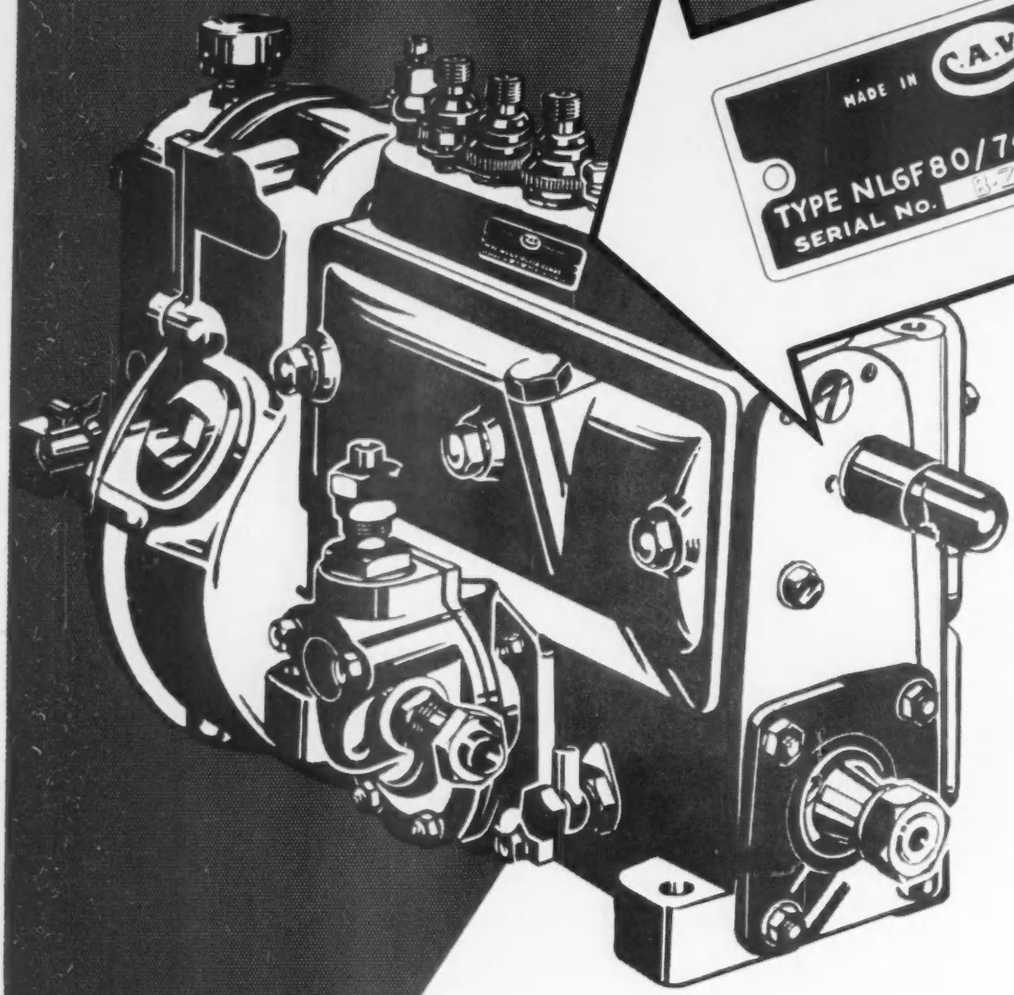

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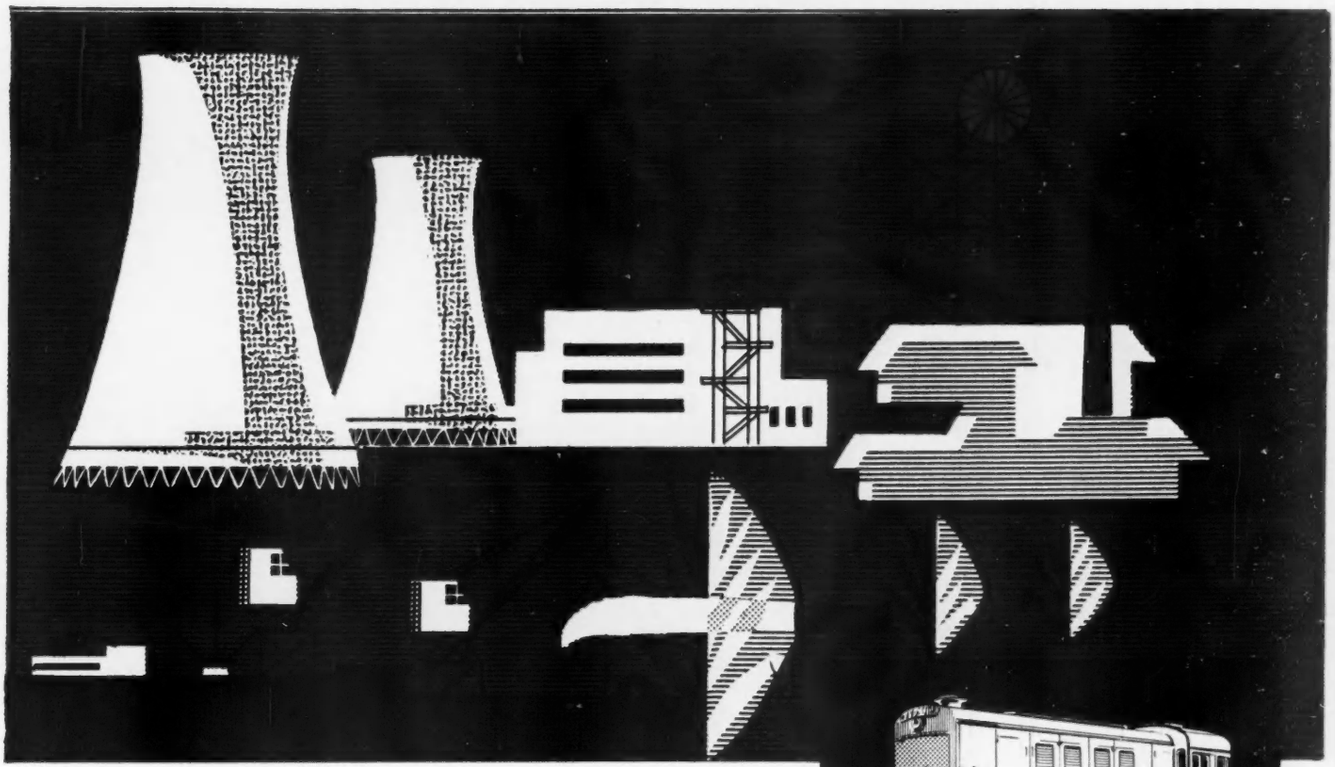

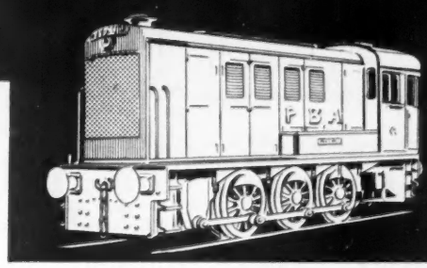

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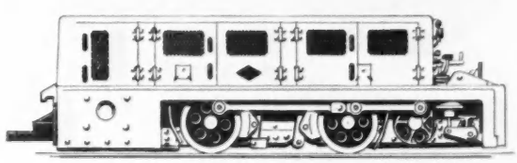

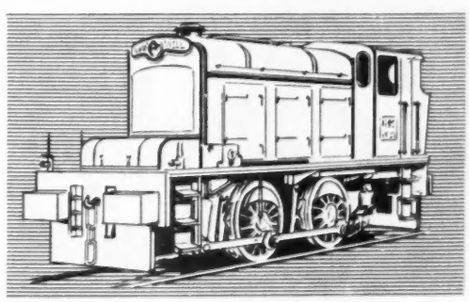

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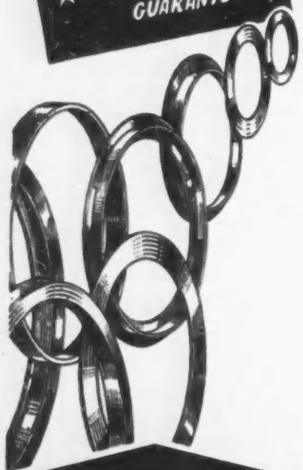

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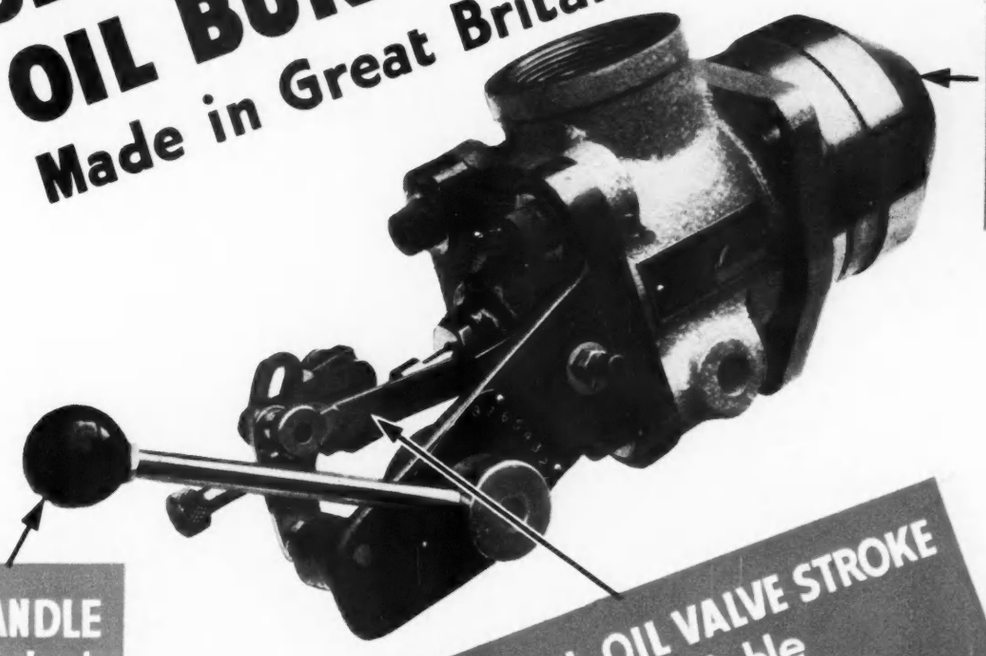

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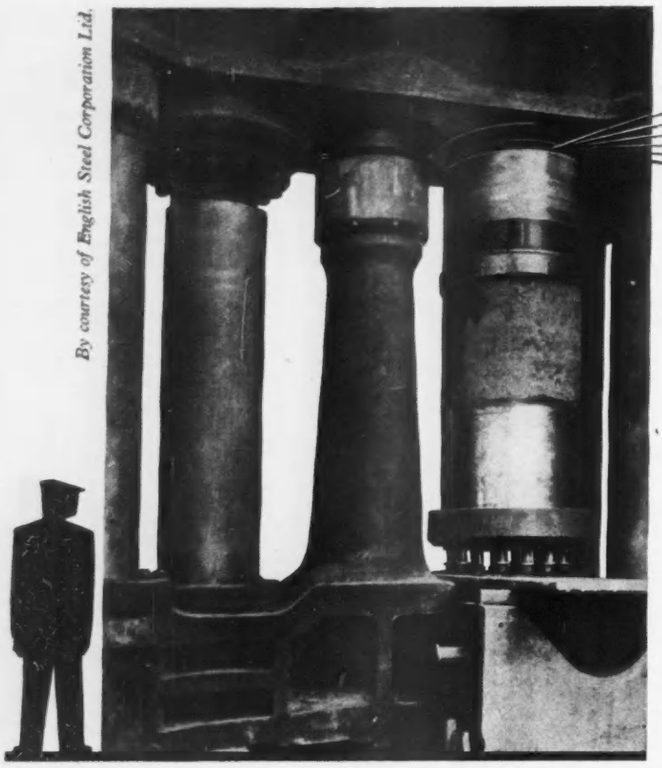

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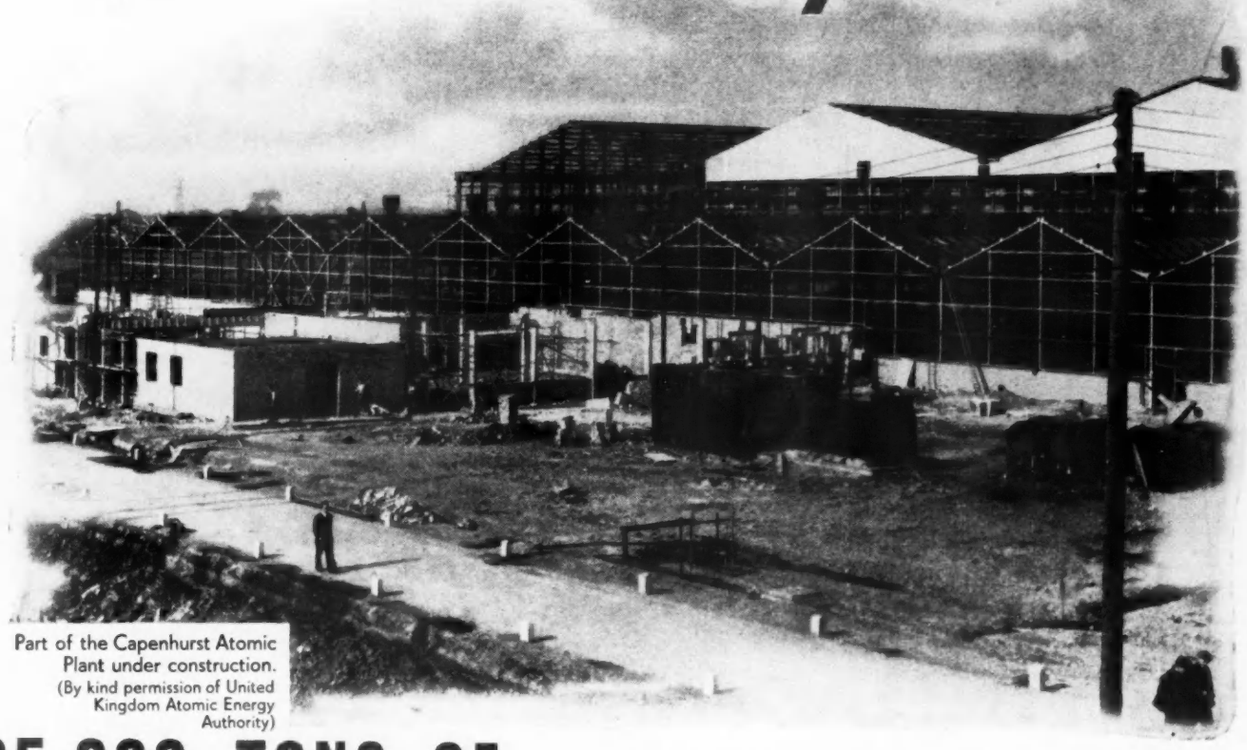

Part of the Capenhurst Atomic Plant under construction.
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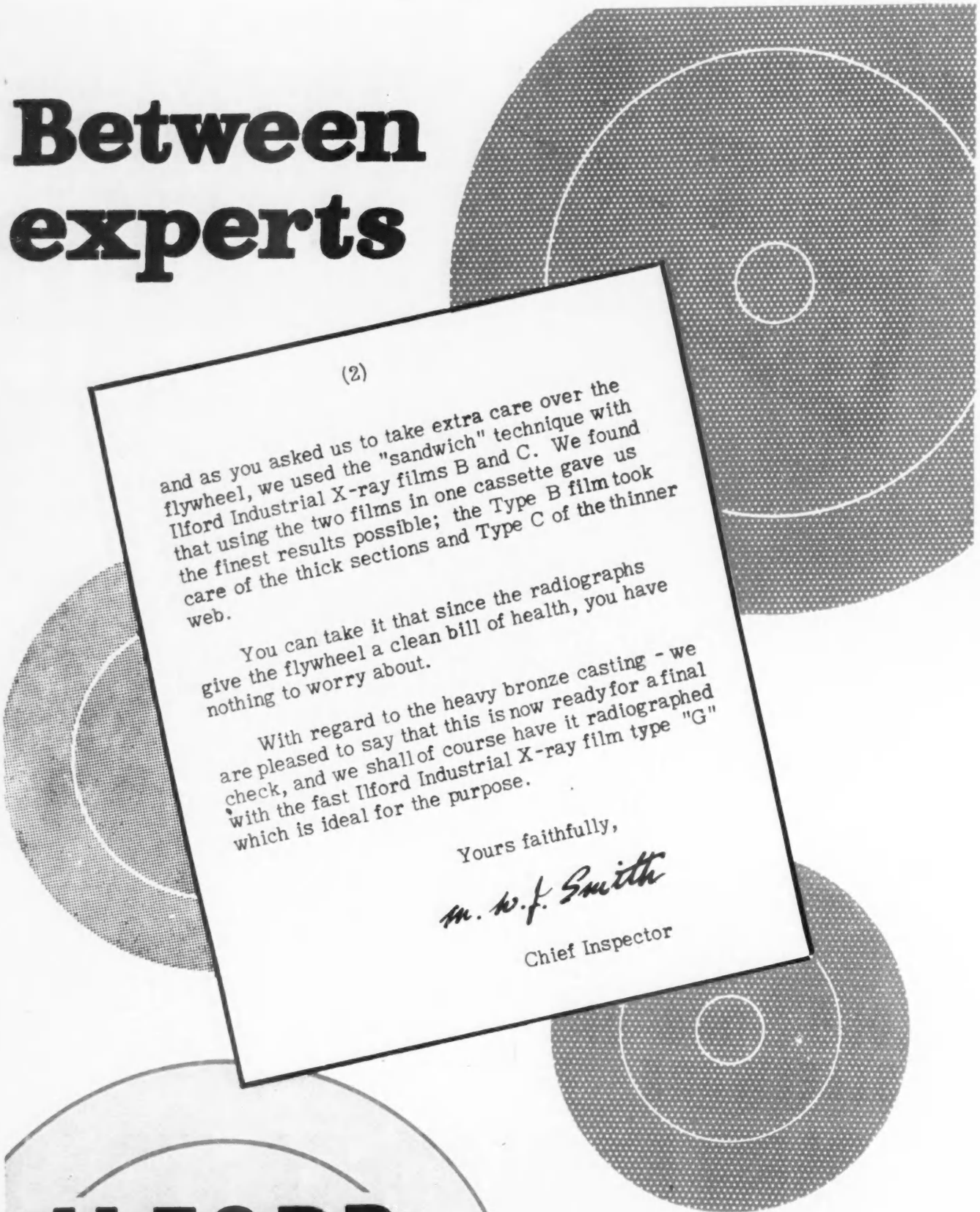
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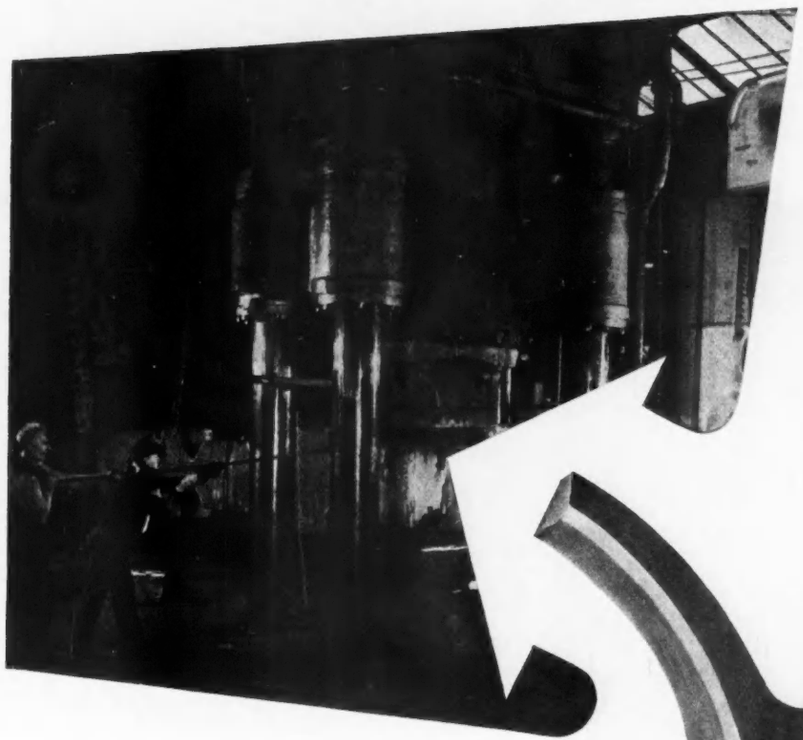

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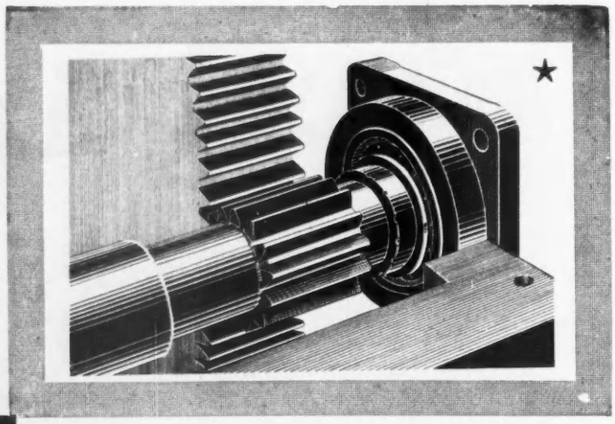

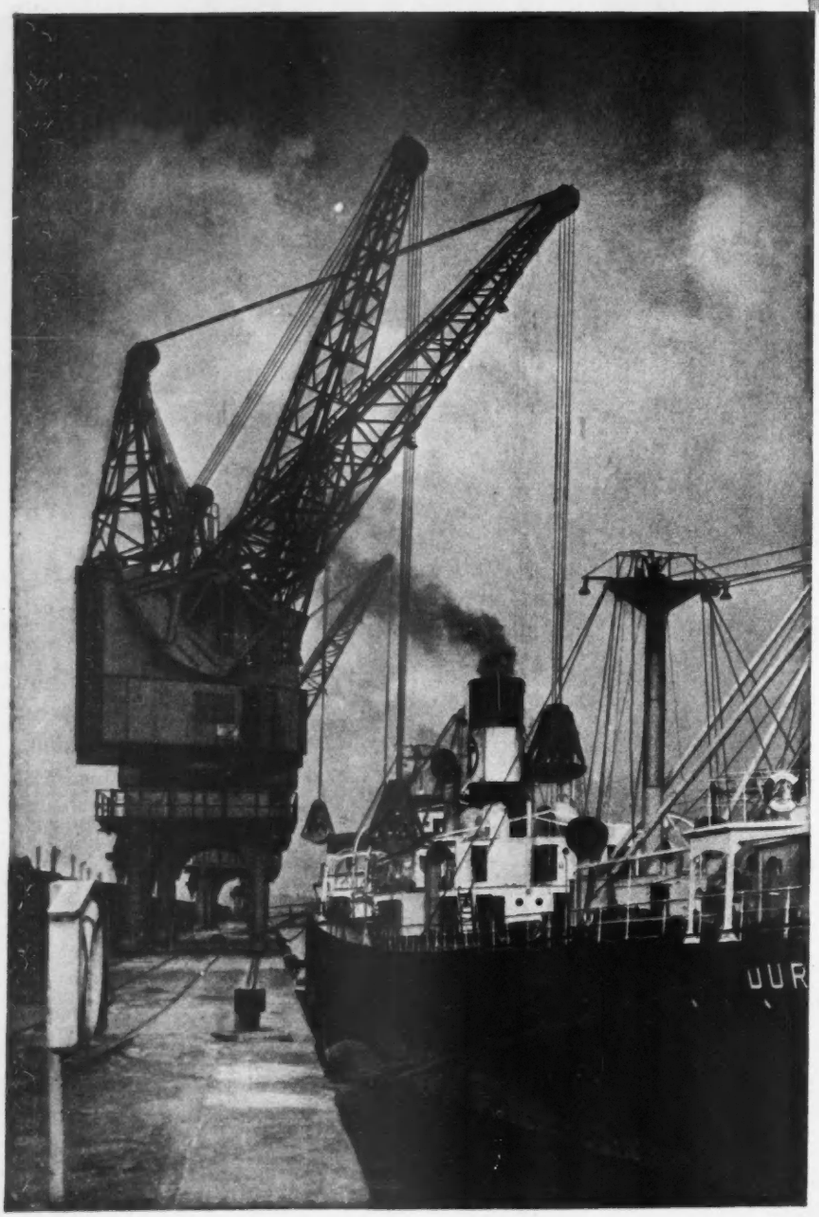

Clyde 7½ ton Level Luffing Cranes at work on the Manchester Ship Canal.

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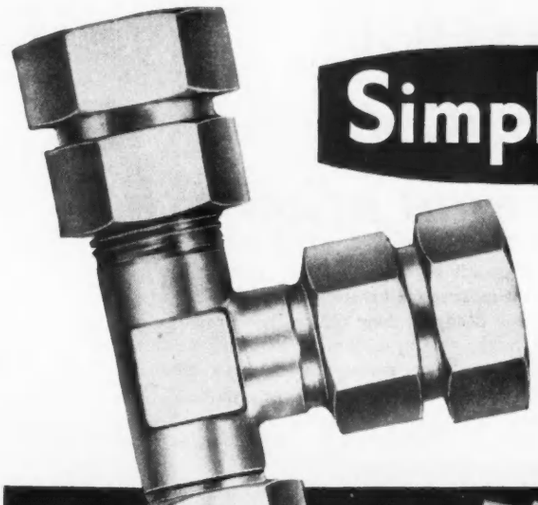

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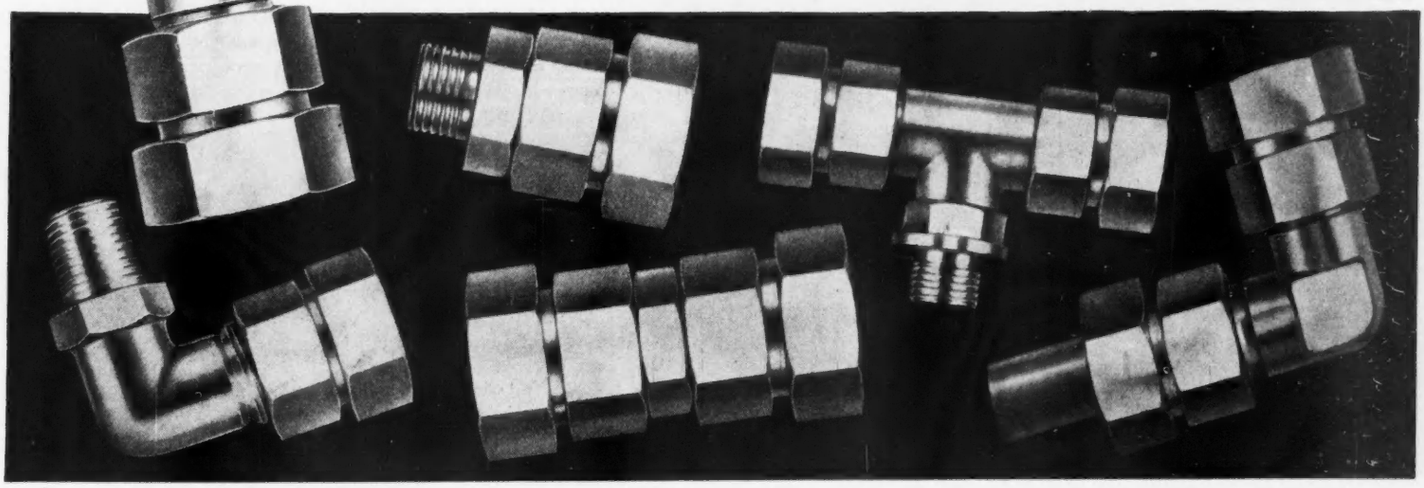

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Barimar have a couple of excellent reasons for congratulating themselves on this particular job of welding.

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—NOW FOR THE SECOND:

REASON TWO

That the damaged Crankshaft was shipped to Barimar by customers in The Middle East.

WHAT A TRIBUTE TO THE STEADILY-GROWING REPUTATION ENJOYED BY BARIMAR OVERSEAS!

THE PICTURES tell the story of this outsize job of welding, and give some idea of Barimar's facilities for handling "casualties" whatever their size.
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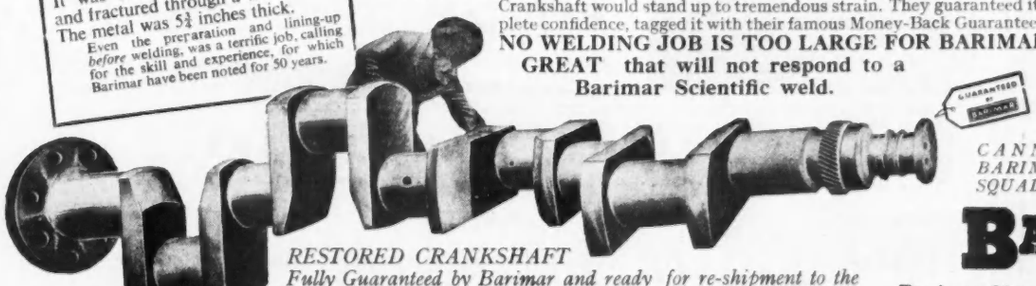

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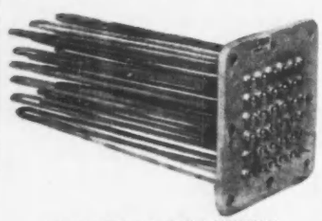

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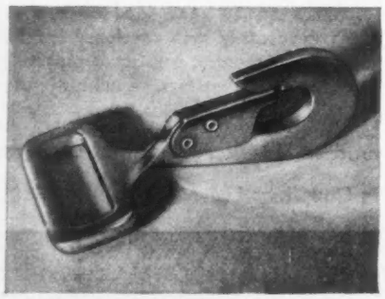

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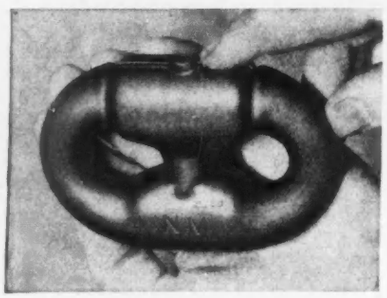
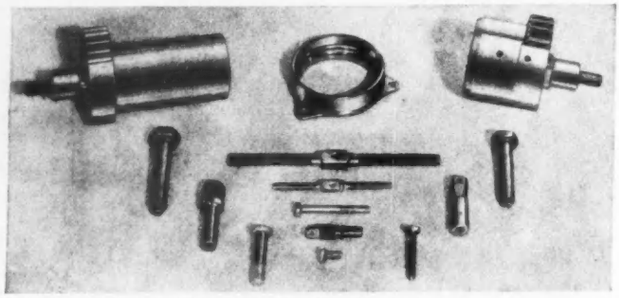


A non-magnetic Anchor Chain link made of 'K' MONEL.



A selection of 'K' MONEL *bolts and rivets used in various parts of aircraft.*

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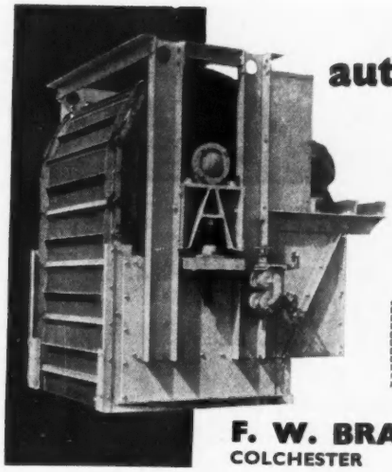

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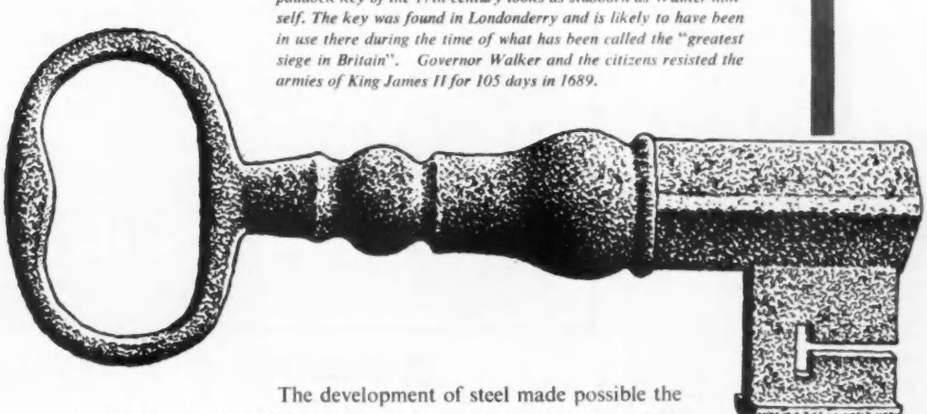

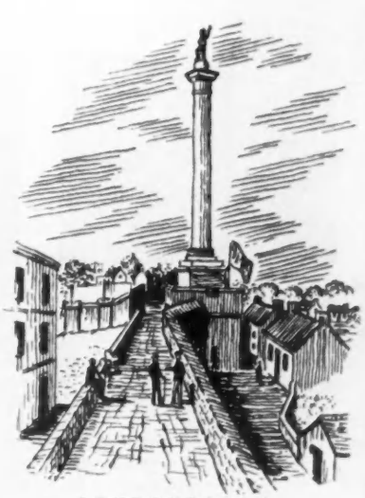

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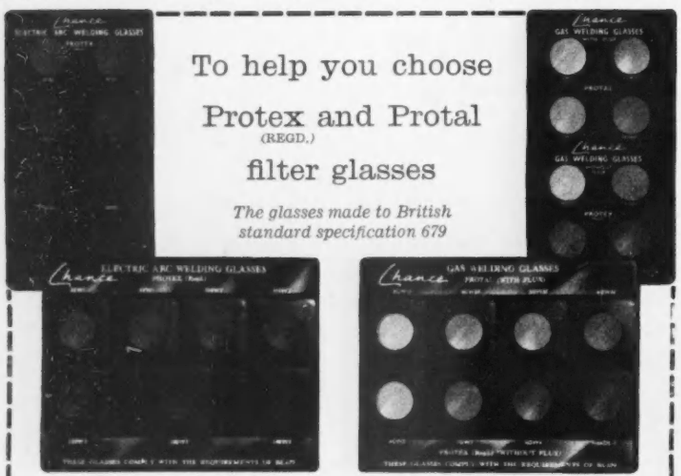

TOP: PROTEX (REGD.) ELECTRIC ARC WELDING GLASSES — PROTAL & PROTEX (REGD.) GLASSES for gas welding with and without flux
CARD SIZE 7¾ x 4¼

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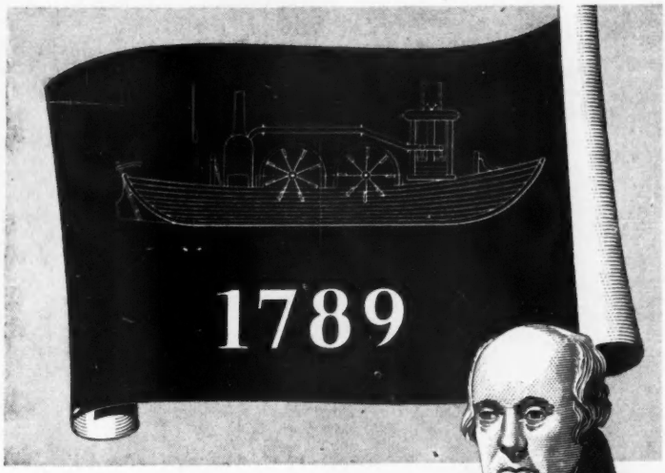

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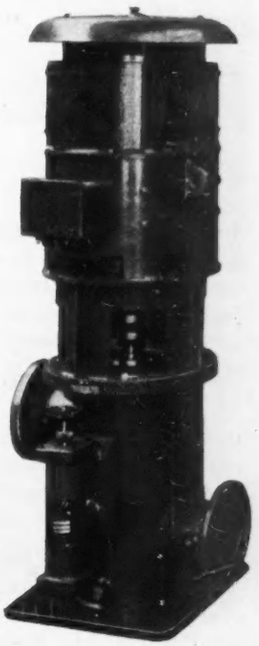

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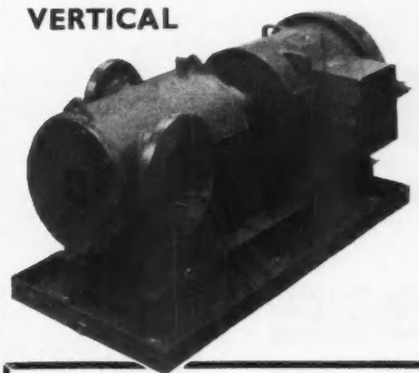

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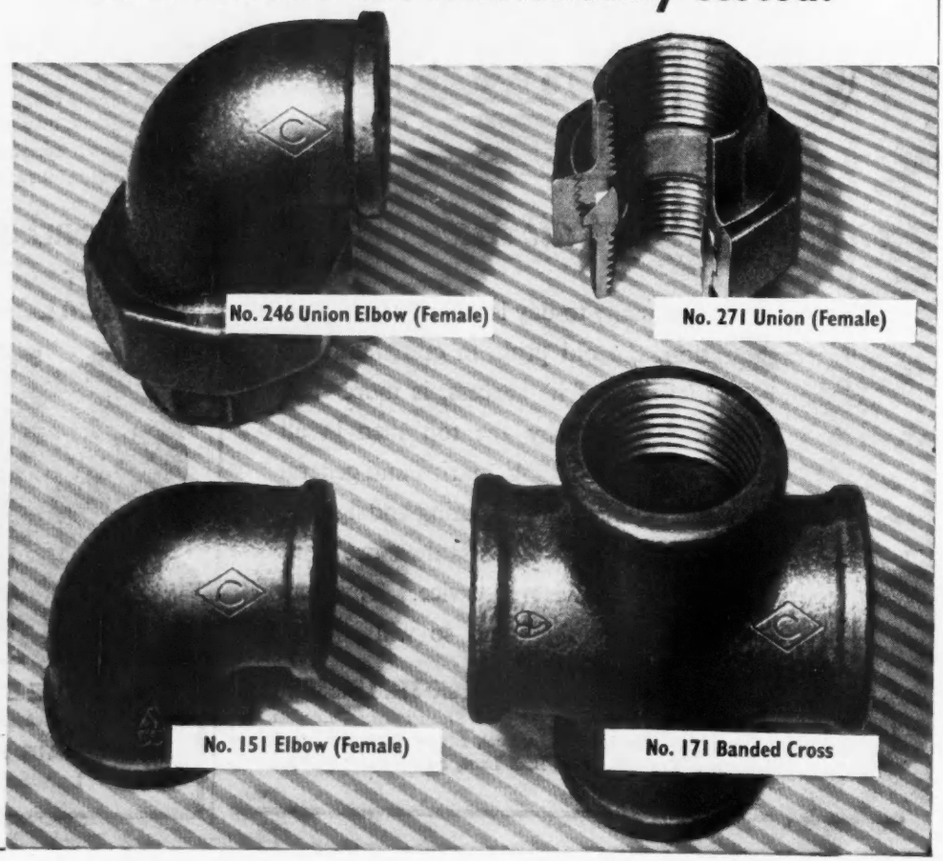

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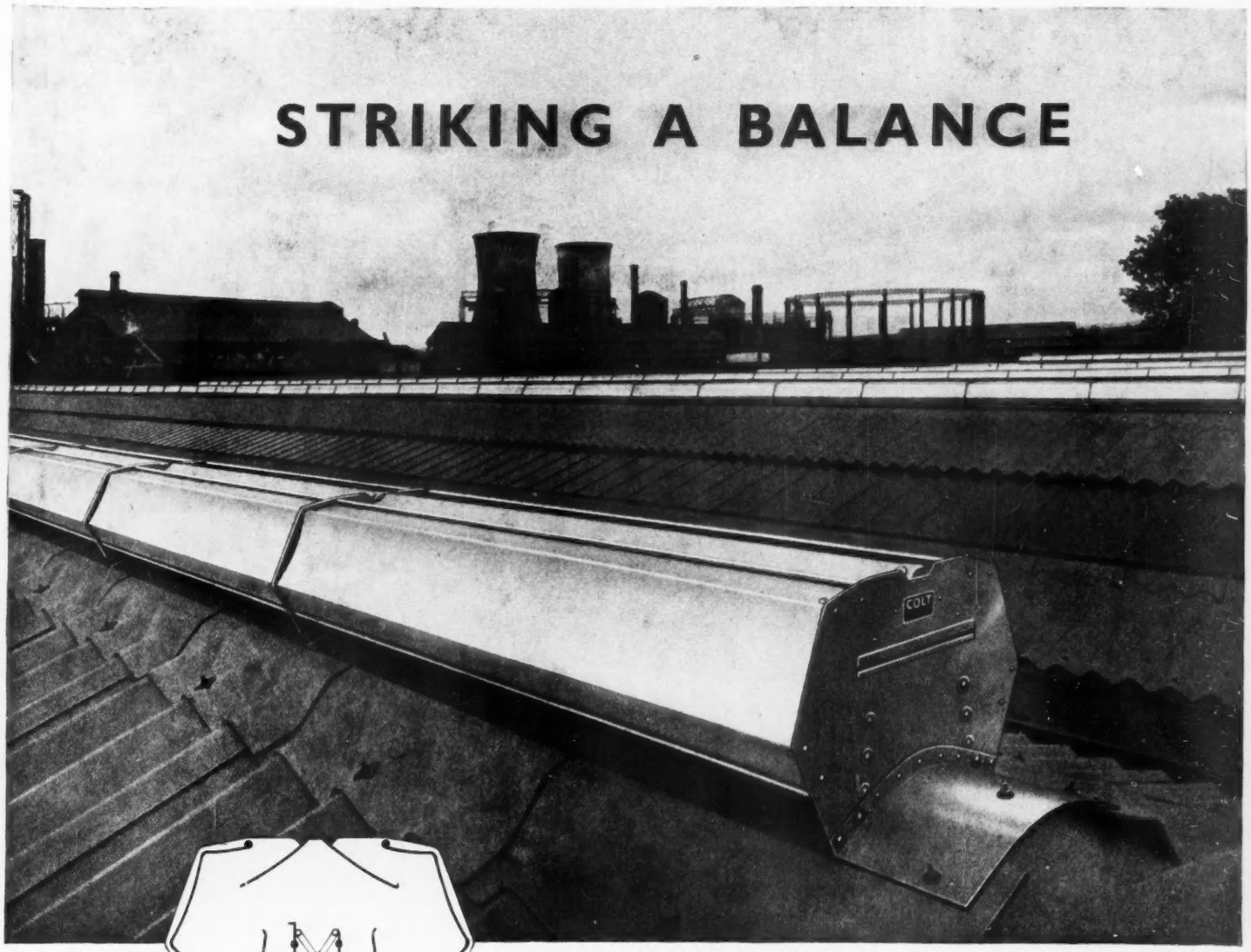

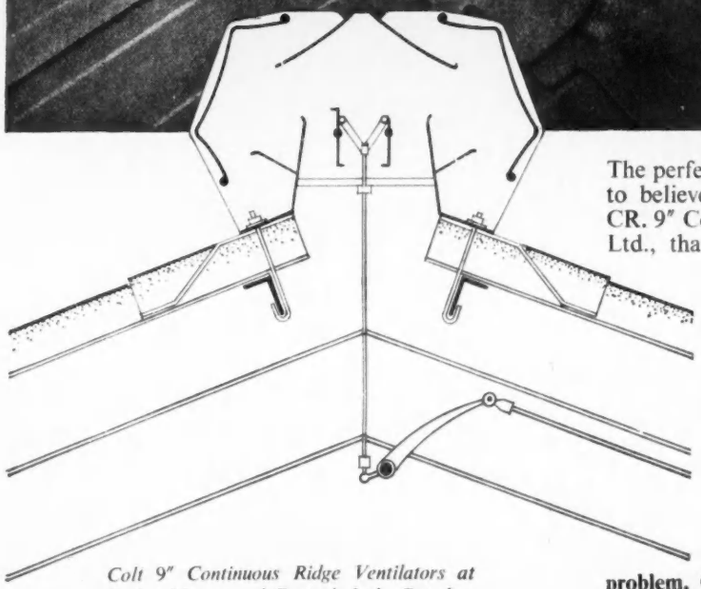

Colt 9″ Continuous Ridge Ventilators at Bailey Meters and Controls Ltd., Croydon, Surrey. Architect: Reginald Lone, F.R.I.B.A., F.R.I.C.S., F.R.San.I.

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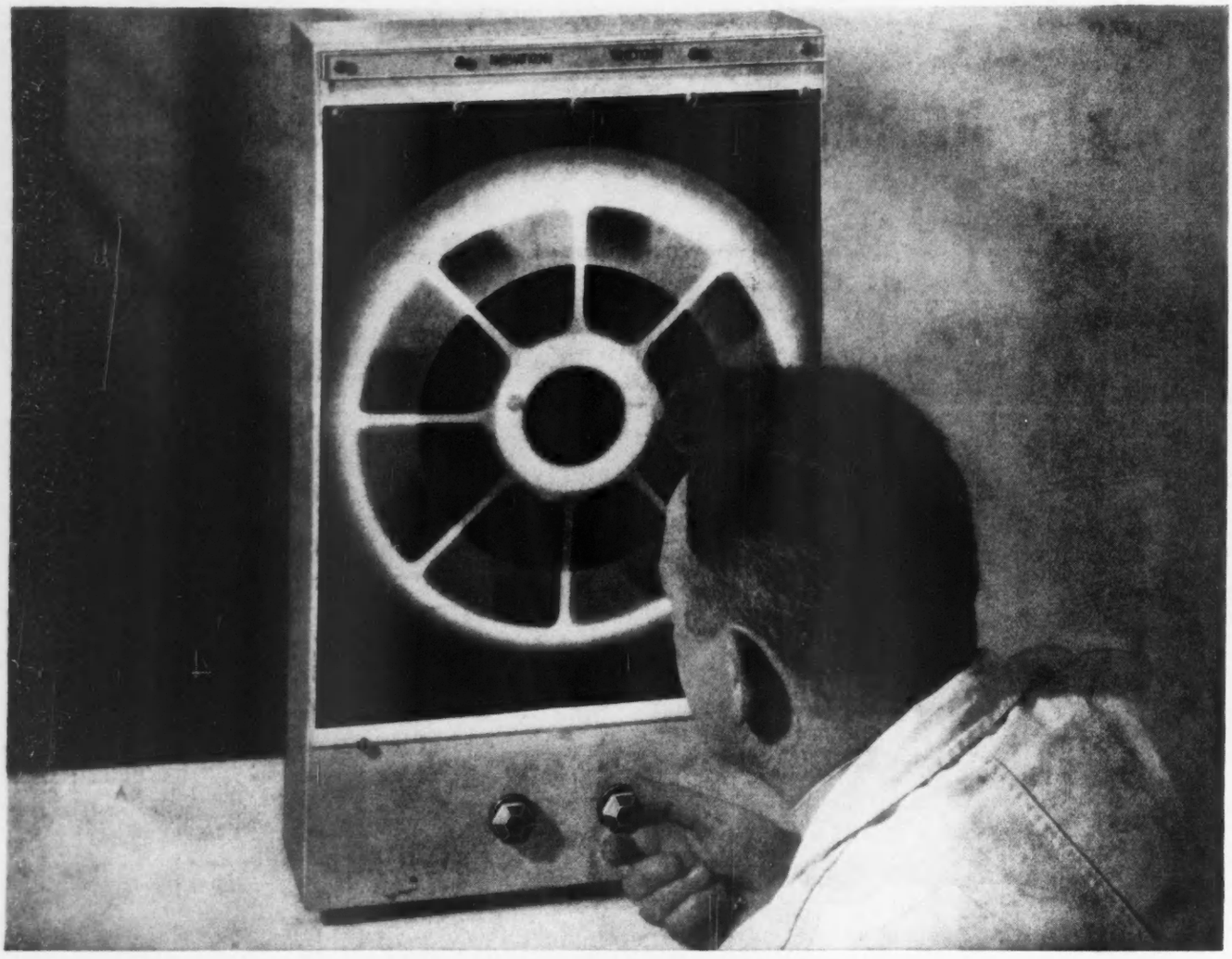

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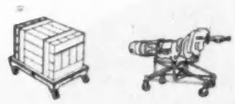

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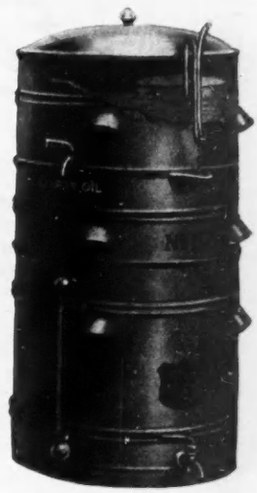

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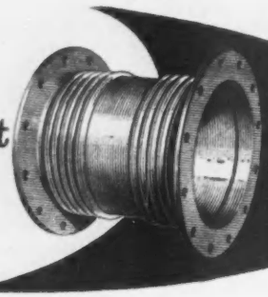
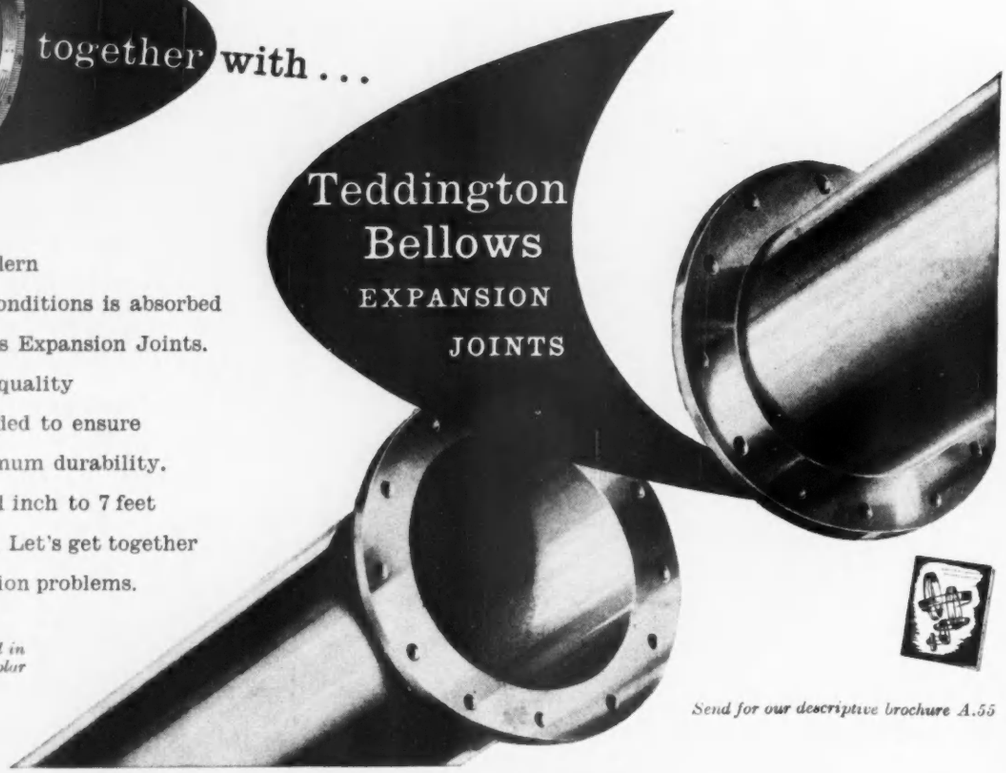
Let's get  together with . . .

Teddington Bellows EXPANSION JOINTS



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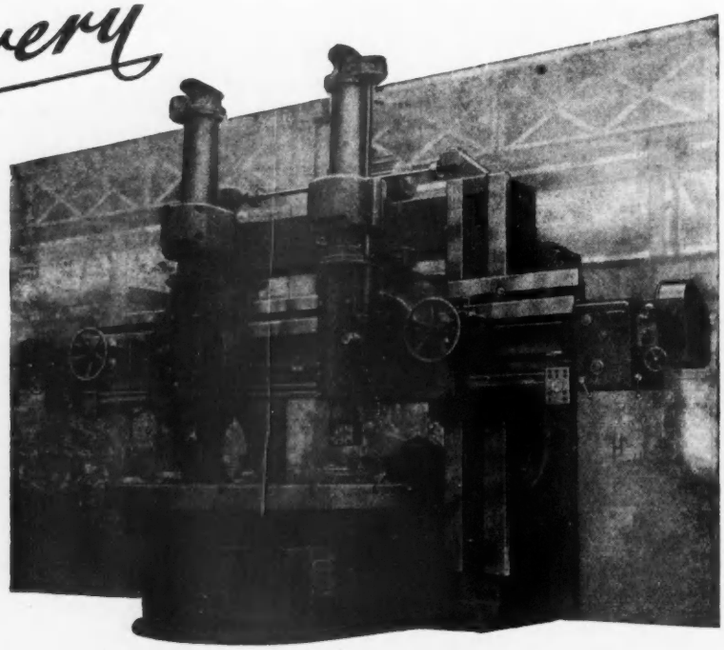

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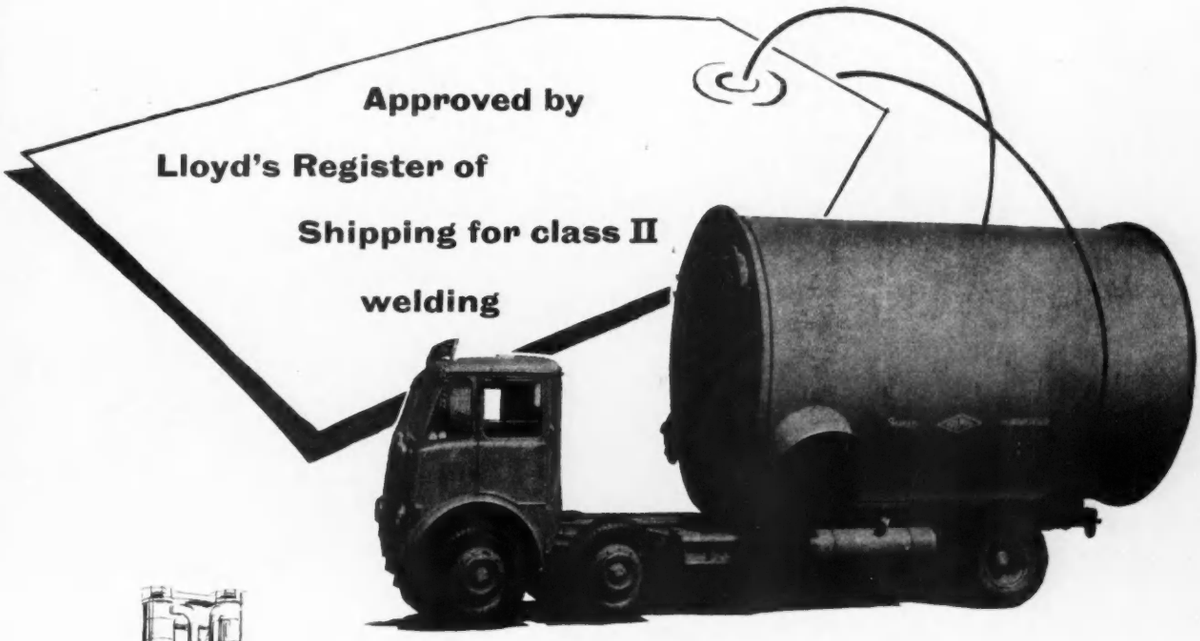

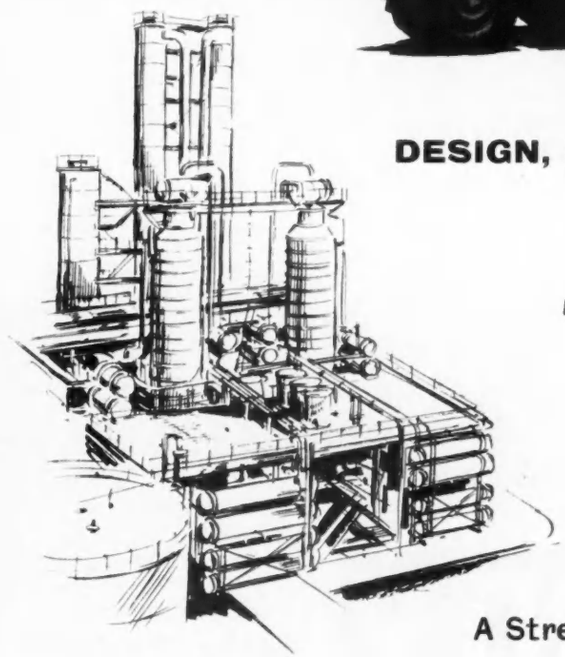

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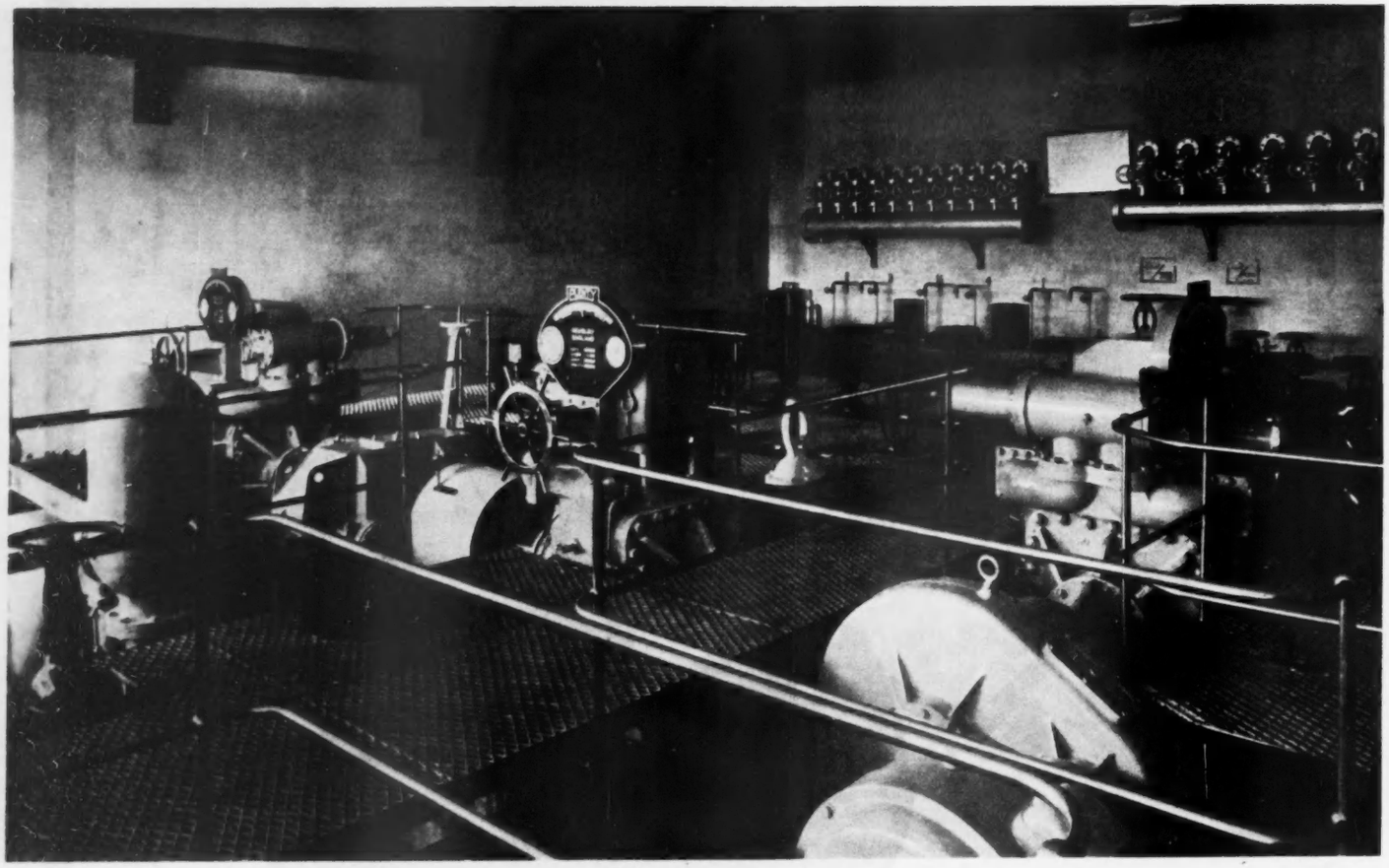

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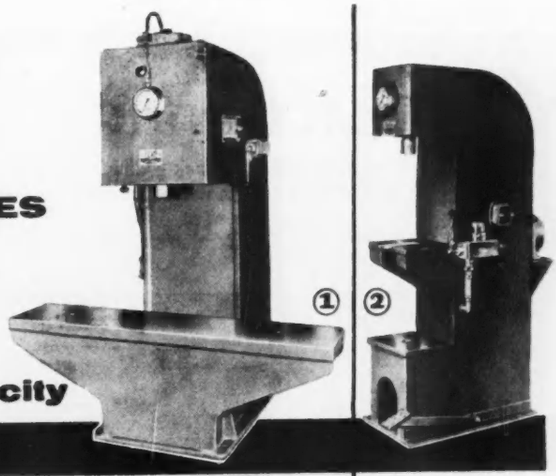

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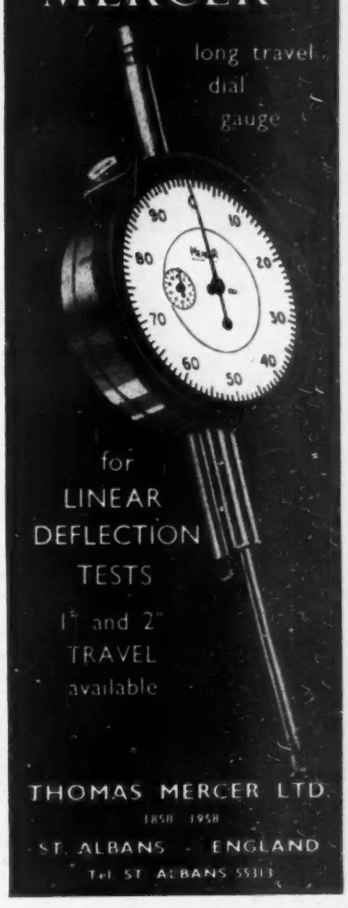

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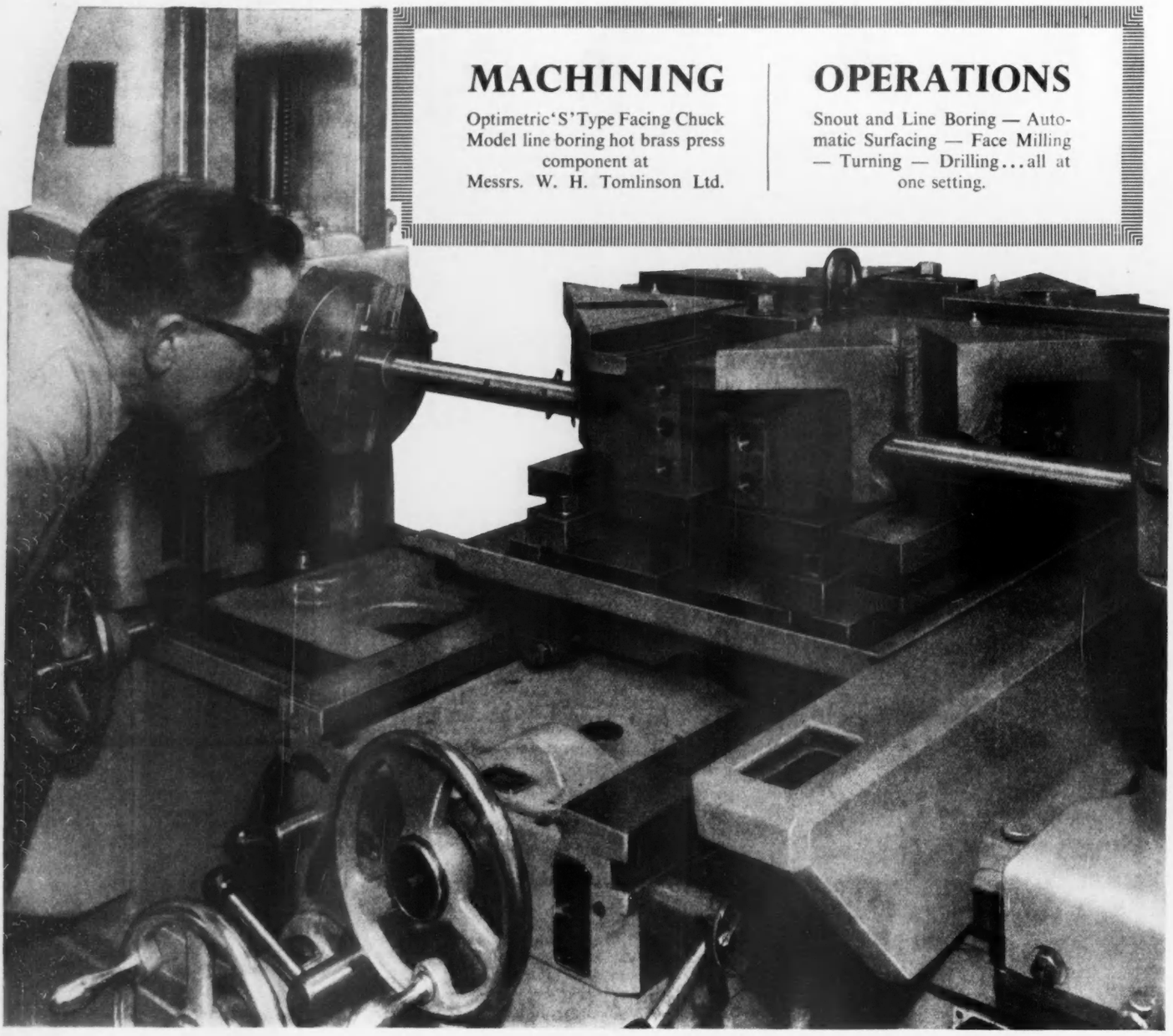

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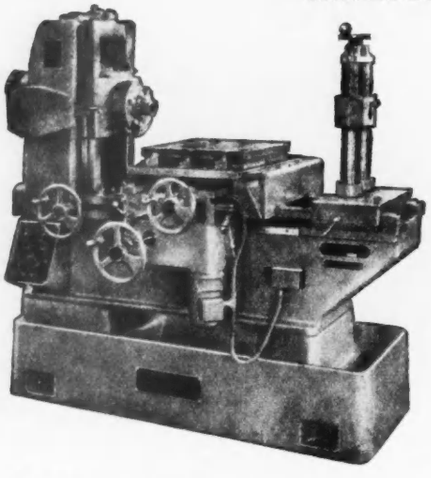

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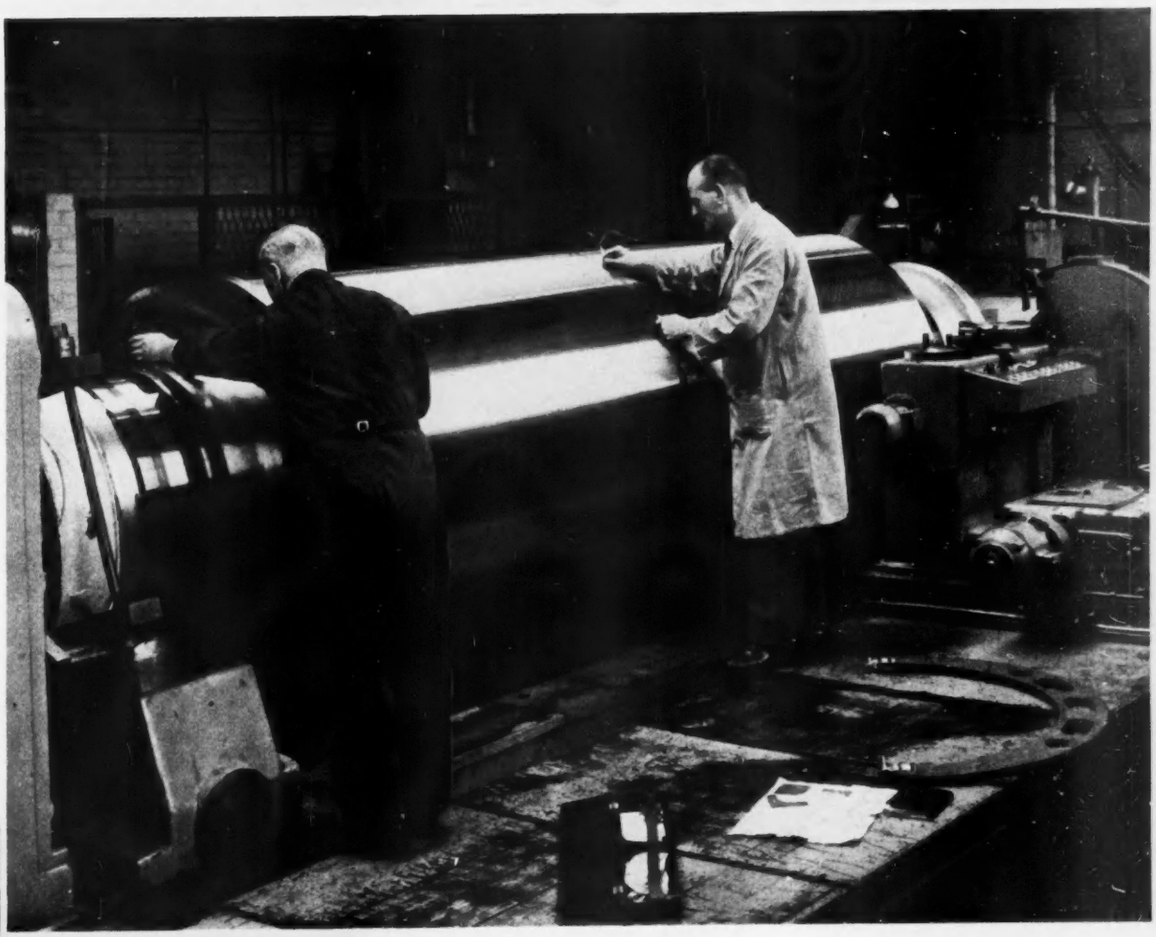

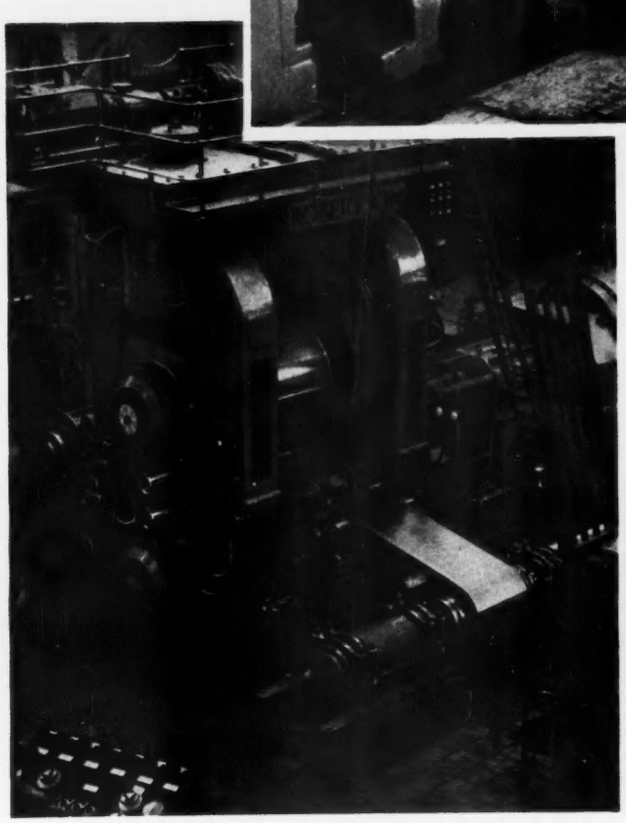

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SILENTBLOC LTD., MANOR ROYAL, CRAWLEY, SUSSEX, Telephone: CRAWLEY 2100.
Subsidiary—The Andre Rubber Co. Ltd.

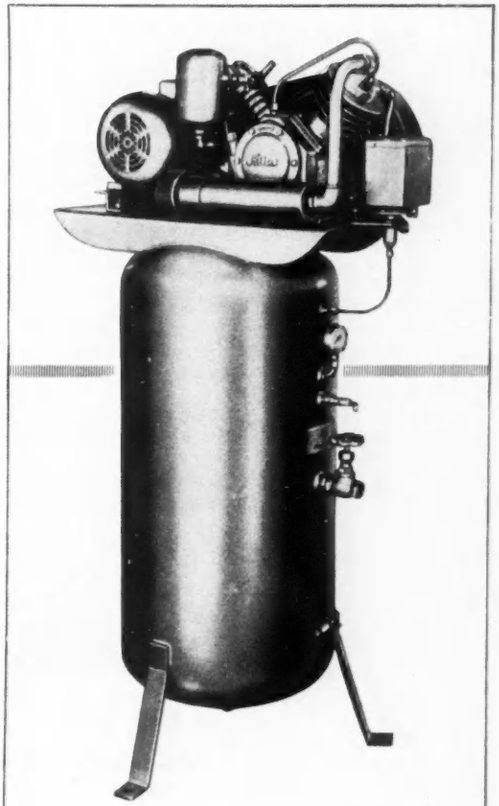
TAB/EB 28

KE6 RAS, Single stage twin cylinder compressor unit, working pressure 100 psi maximum with 7.5 hp motor. 13.4/cu. ft. horizontal air receiver. This type includes pressure switch and unloading device.

PE 2 RAS, Single stage, one cylinder, fully automatic compressor unit with 0.5 hp motor with 1.42/cu. ft. horizontal air receiver.

Complete small compressor range by Atlas Copco

Small workshops or garages where the need for compressed air is limited can find a small compressor which will suit their needs exactly in Atlas Copco's complete range. Here are a few things they will power: *Paint spraying—car hoisting—air for tyres—forced feed lubrication—sand blasting—metal and wood drilling—grinding—screwing and tapping—metal shearing—hoists—plug hole drilling—rivetting—engraving—stone grinding and polishing—operating door openers, etc.*



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How big is your shop? Atlas Copco's compressor equipment is as complete for smaller air users as for larger operations. From fractional horsepower units upwards, there is a versatile range of compressors and compressor units. Petrol and electric driven portables are available. All are fitted with either mechanical or electrical devices for maintaining working pressure without waste of power. All embody the many years of experience that have made Atlas Copco one of the world's leading manufacturers of air compressors.

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Contact your local company or agent or write to Atlas Copco (Great Britain) Limited, Beresford Avenue, Wembley, Middlesex, or Atlas Copco AB, Stockholm 1, Sweden.

KT 2 RGS, Two-stage fully automatic twin, cylinder compressor unit, working pressure 200 psi with 2 hp motor with 6/cu. ft. vertical air receiver.

conveyed safely

To convey safely *care* has to be taken; and with conveyor belting the right point at which *care* should be taken is at the design, development and manufacturing stages. After that it should take *care* of itself, the people who work with it and the load it carries. The unique research and manufacturing facilities of Rubber Improvement Ltd. make certain that Leonex P.V.C. Multiply Conveyor Belting is produced with such *great care* that long life, dependability and safety are ensured.

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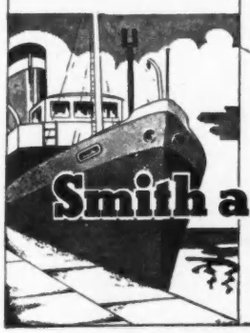

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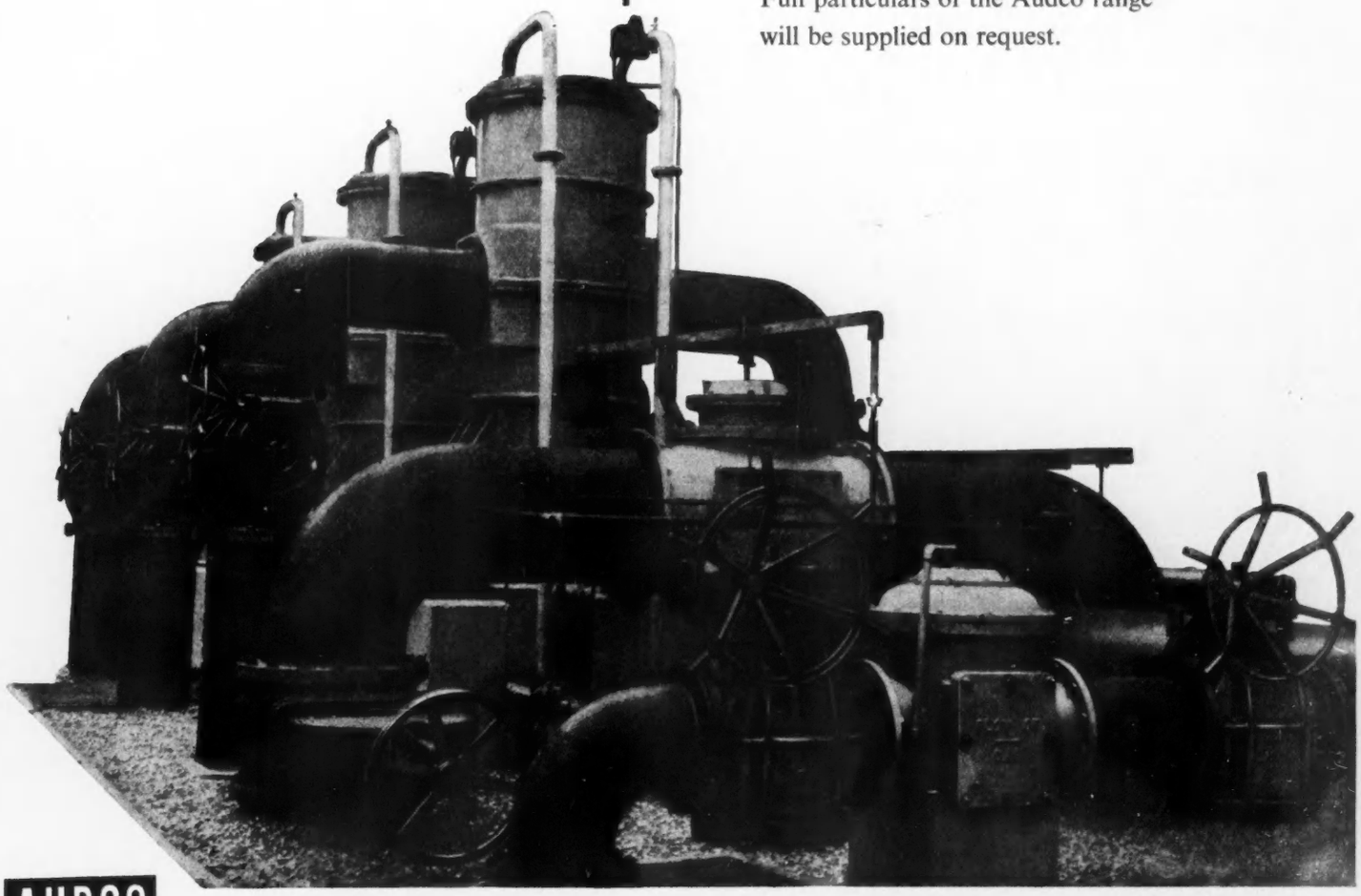

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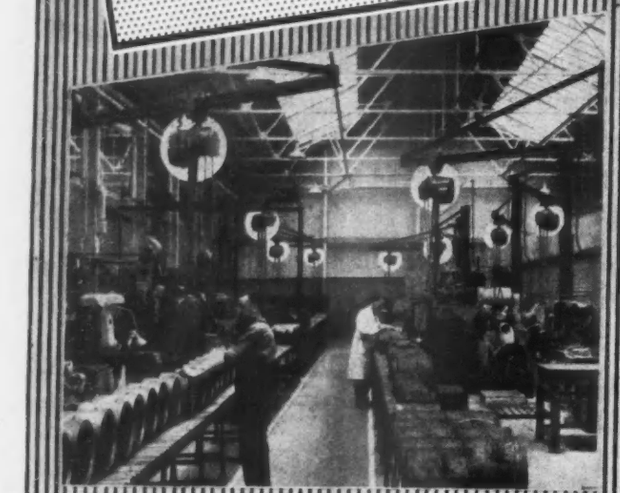

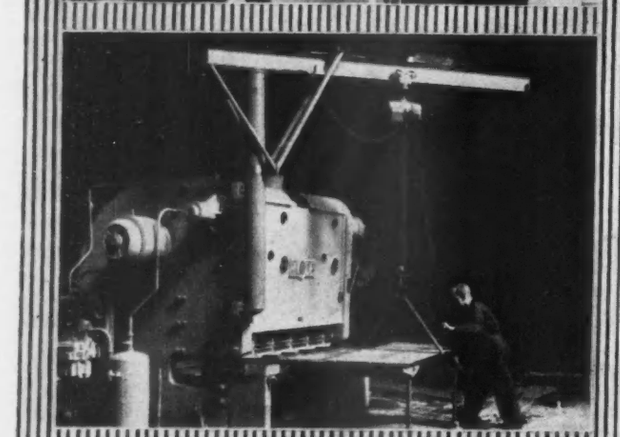

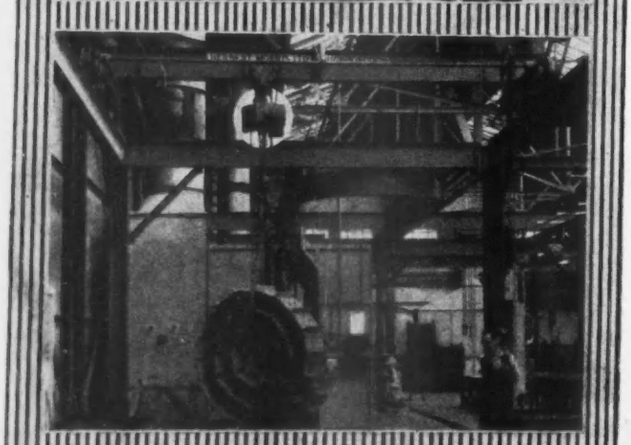

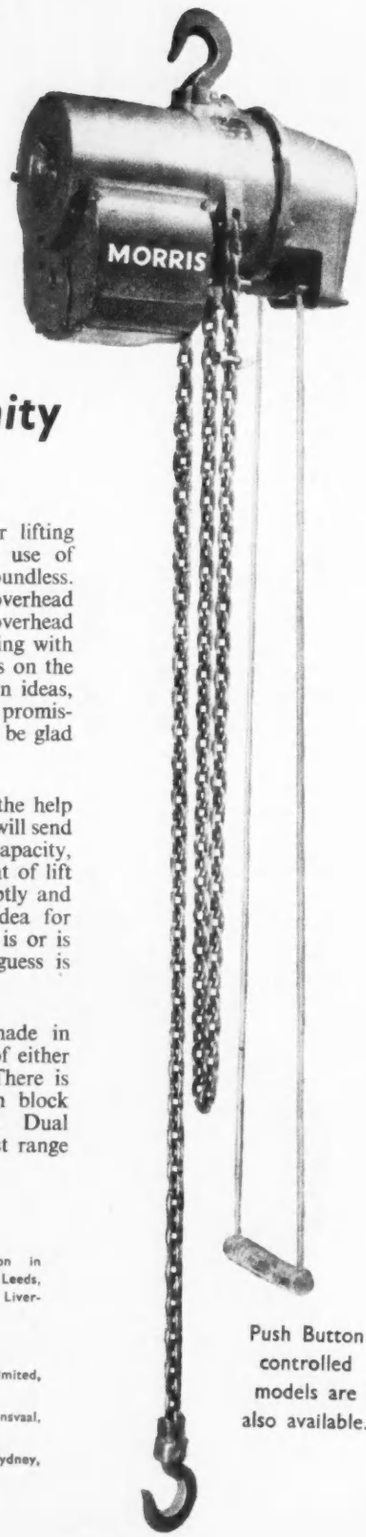

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Select a suitable type of hoist with the help of our folder Section 80/3 (which we will send you on request), let us know the capacity, electric current supply and the height of lift required, and you can decide promptly and on the spot whether your latest idea for speeding up a routine job of lifting is or is not a practical proposition. Our guess is that it will be !

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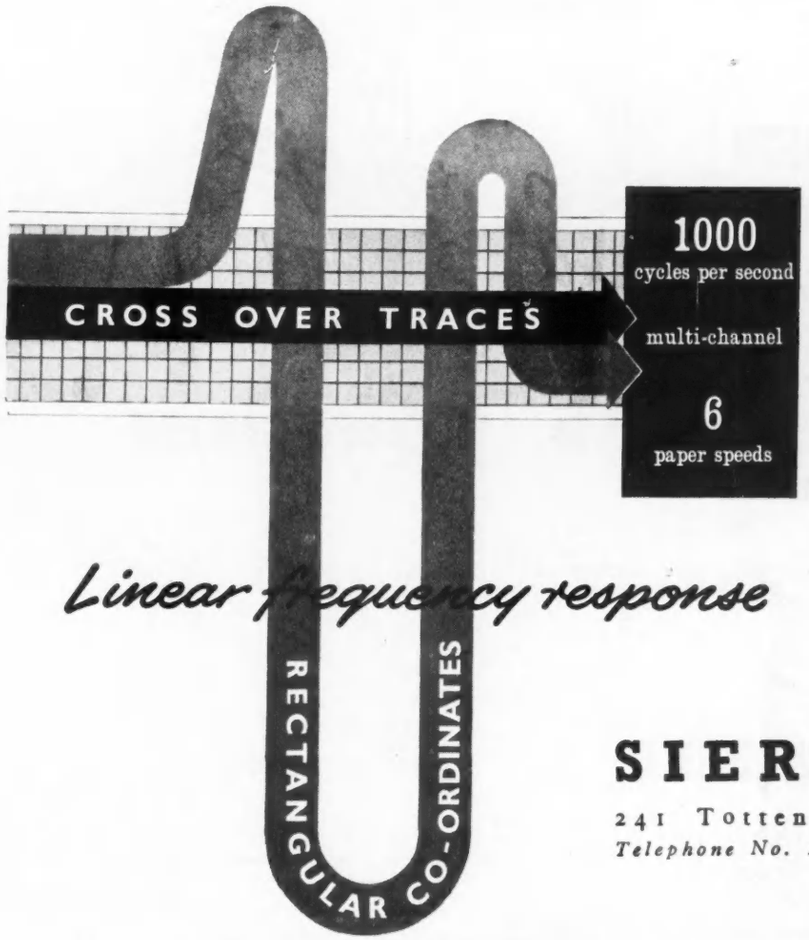

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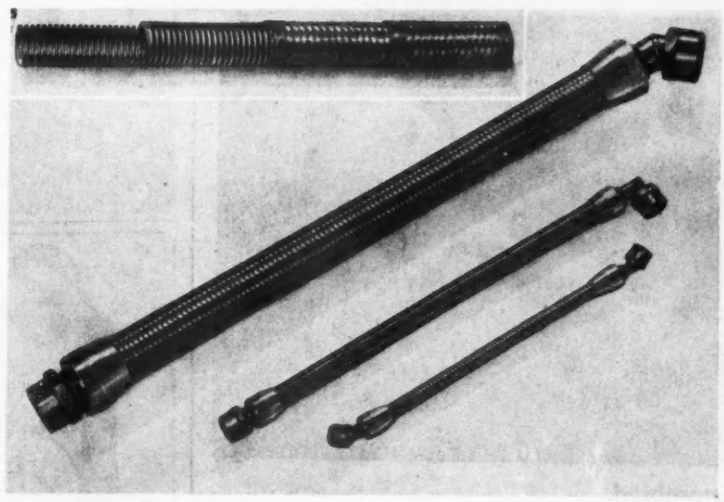

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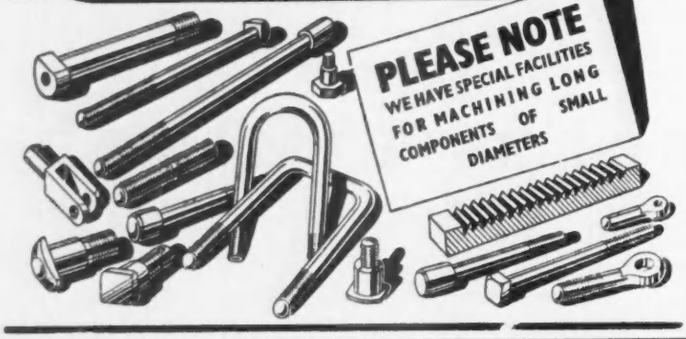

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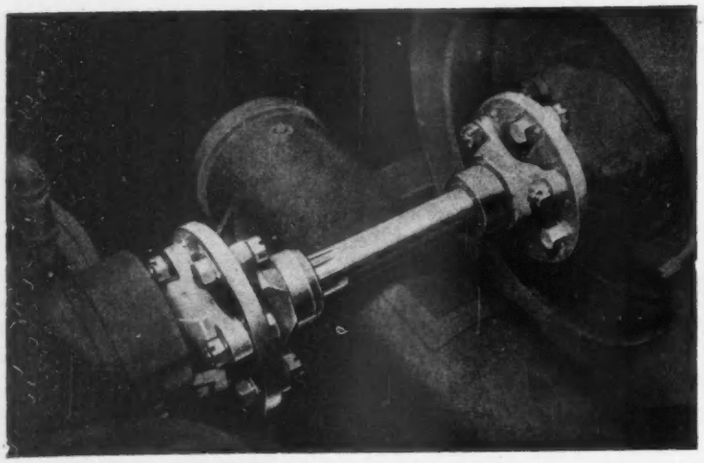

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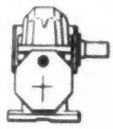

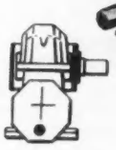

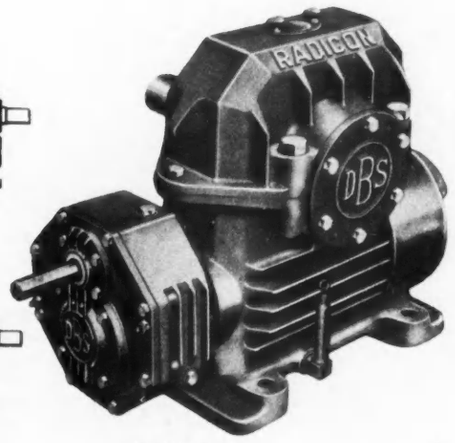

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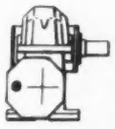

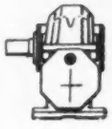

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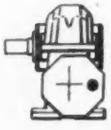

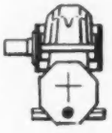

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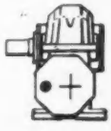

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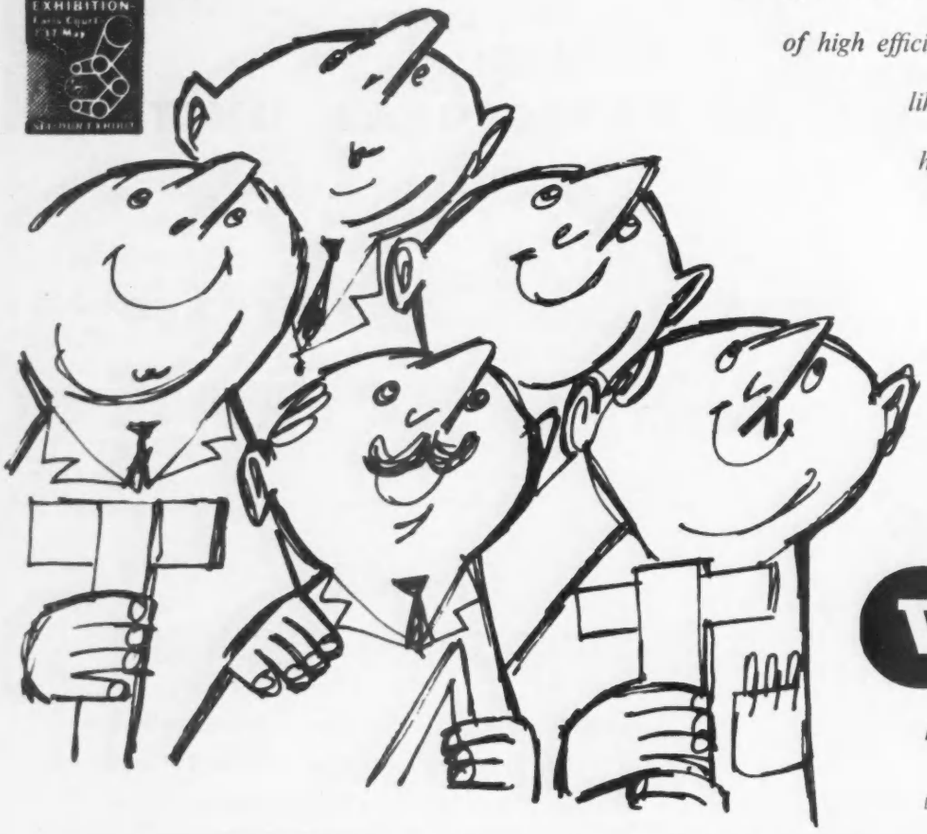
Here we've put another Wiseman gear unit

MECHANICAL HANDLING EXHIBITION

NO. 1



Designers—bless their happy hearts! like to think in terms of high efficiency and whenever possible put something like this 40/1 *meaning "here we must have a Wiseman totally enclosed gear unit". Thus are many tricky power transmission problems solved. Should things get out of hand we can always ask Wiseman to send someone along who is well up in these matters.*

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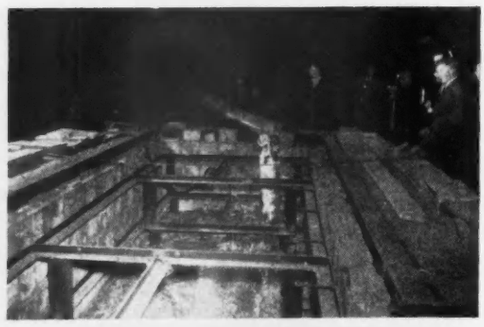

2 *Starting up with 30% virgin zinc and 70% molten zinc pumped from existing bath.*

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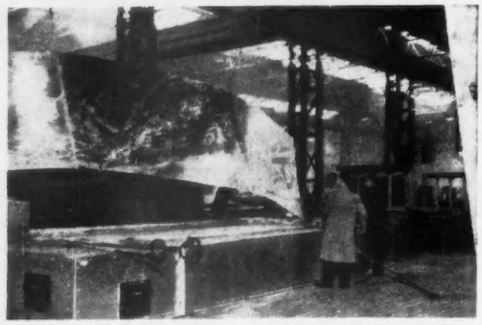
3 *Completed galvanizing furnace showing specimen after dipping.*



4 *Oil storage equipment comprising 2-10,000 gal. storage tanks, heater, filters and pump.*

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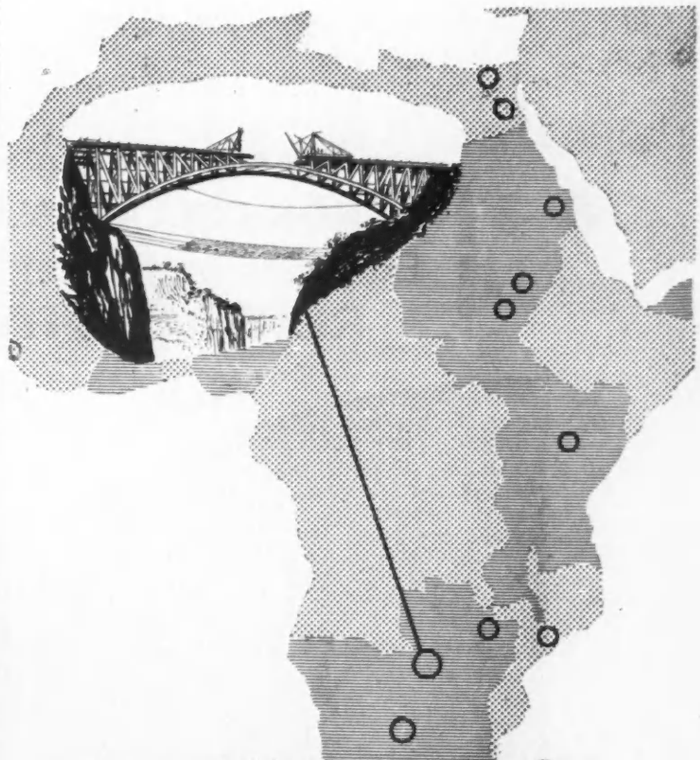

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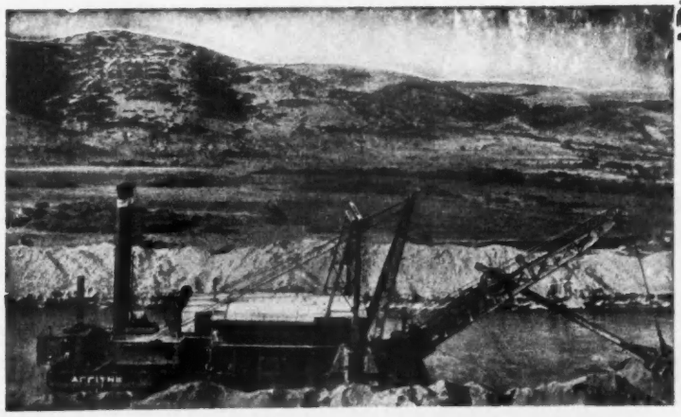

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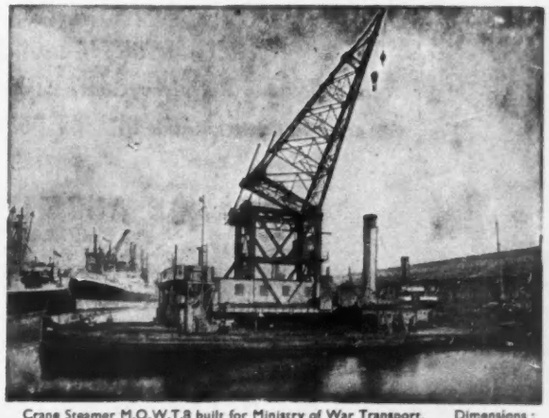

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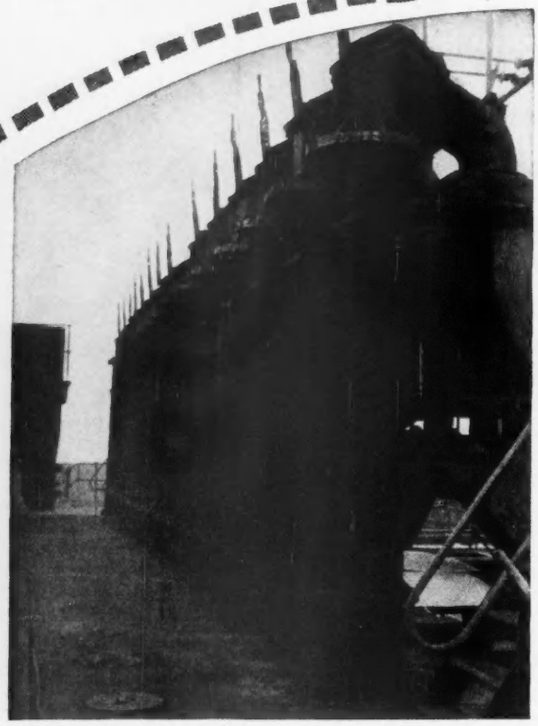

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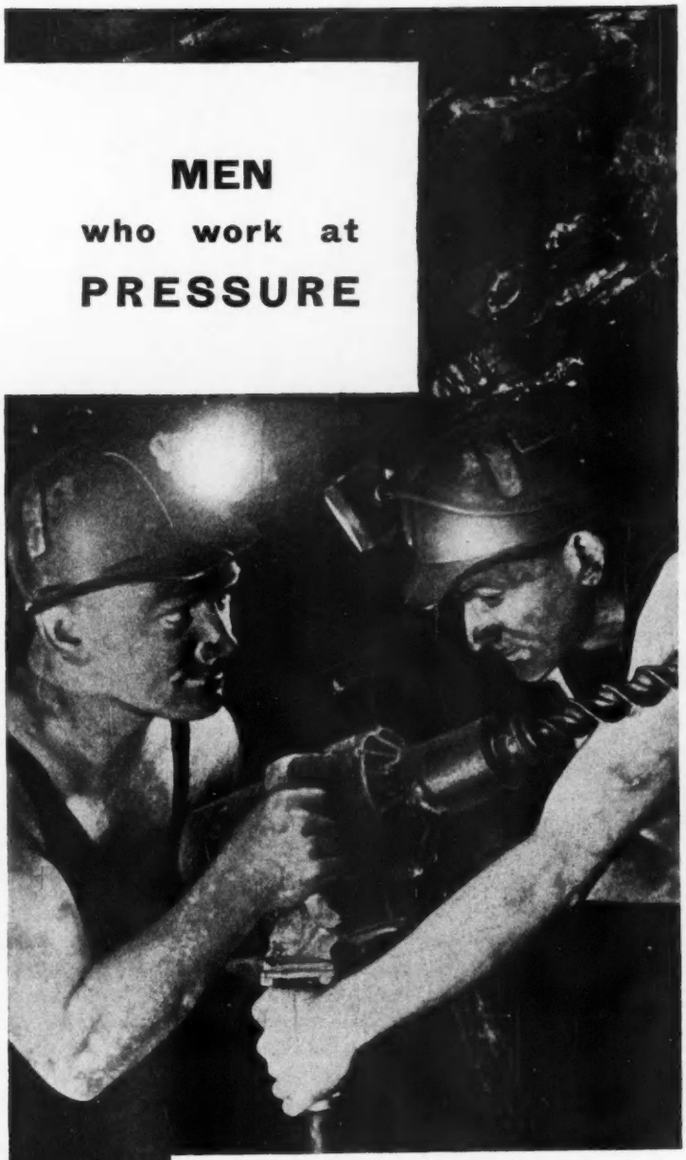

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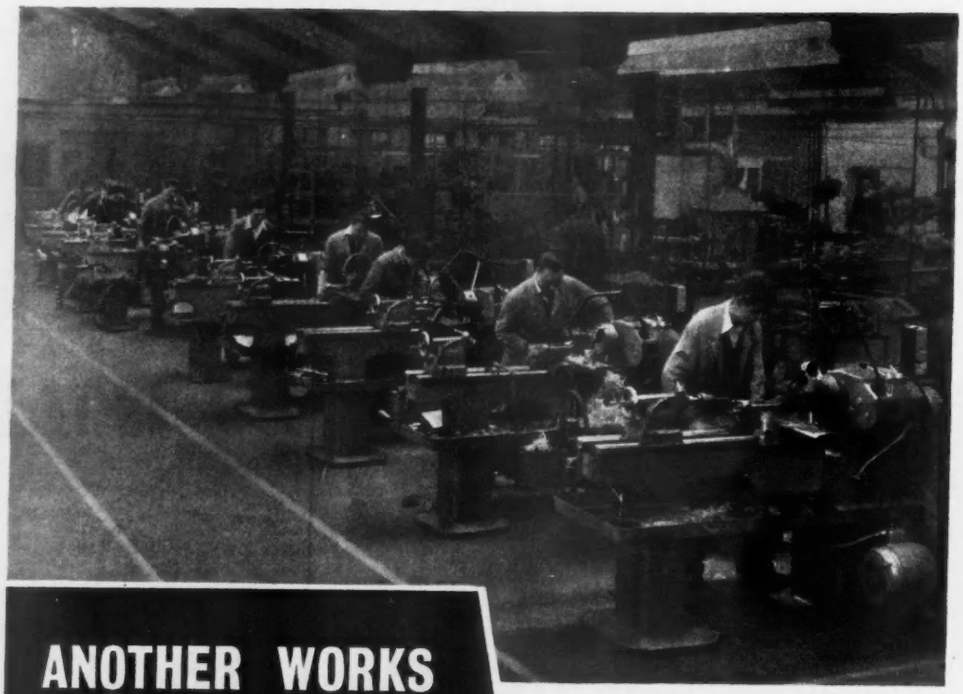

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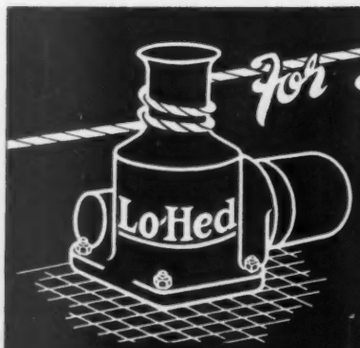

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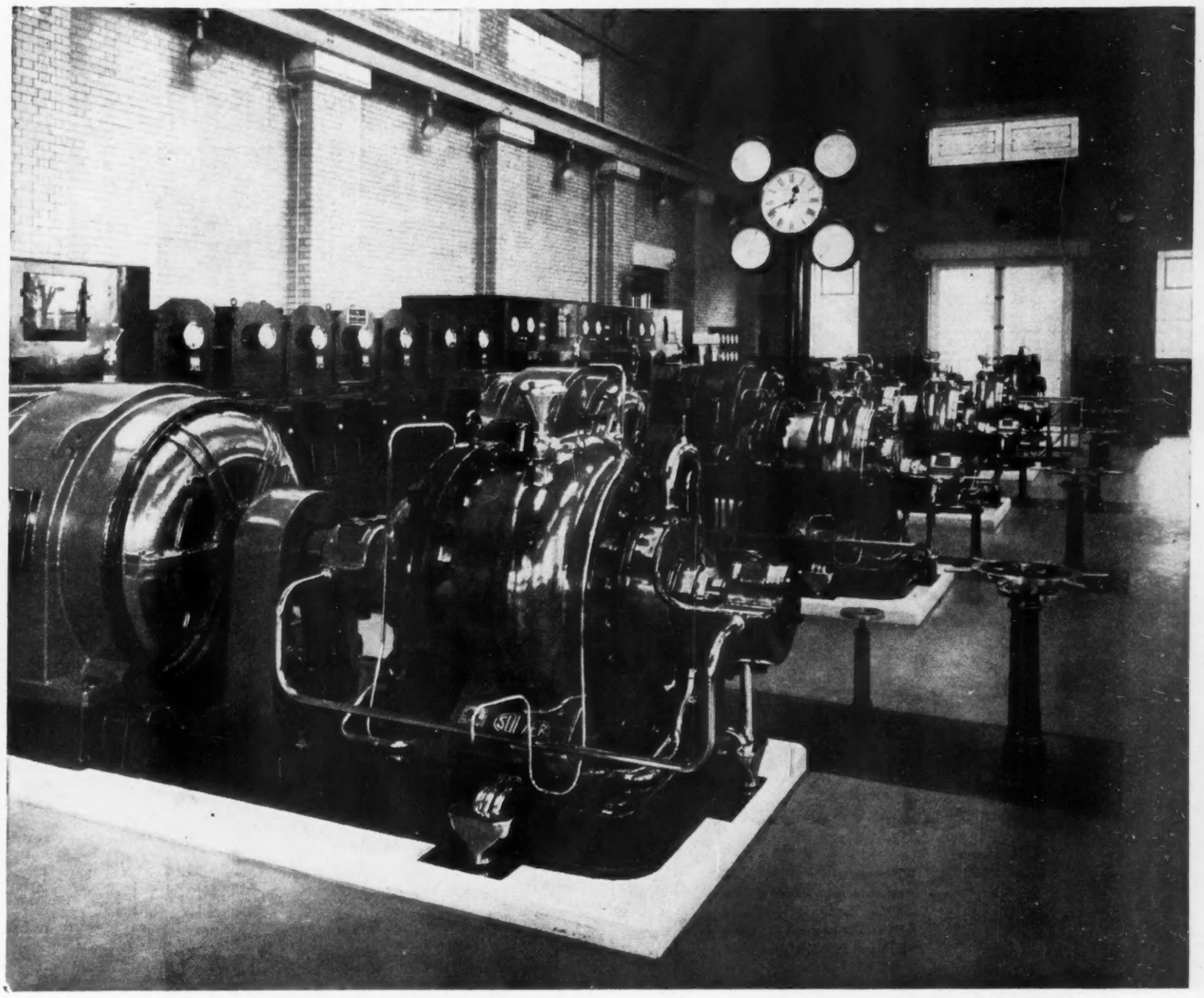

Seedy Mill Pumping Station of the South Staffordshire Waterworks Company. *R. A. Robertson, Esq., B.Sc., M.I.C.E., Engineer-in-Chief.* The illustration shows seven of the fourteen Sulzer Centrifugal Pumping Sets installed at this station.

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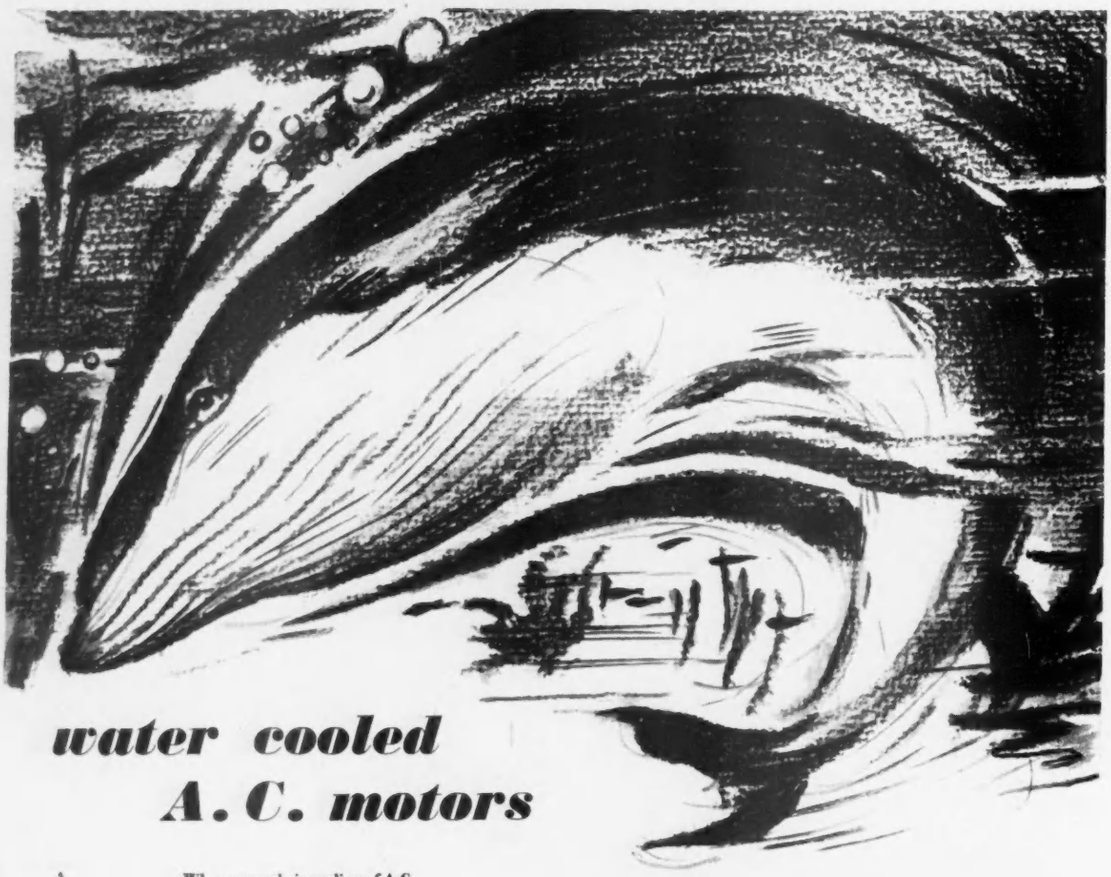

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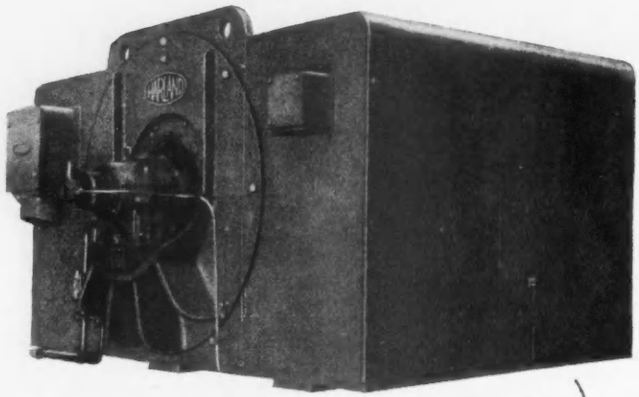

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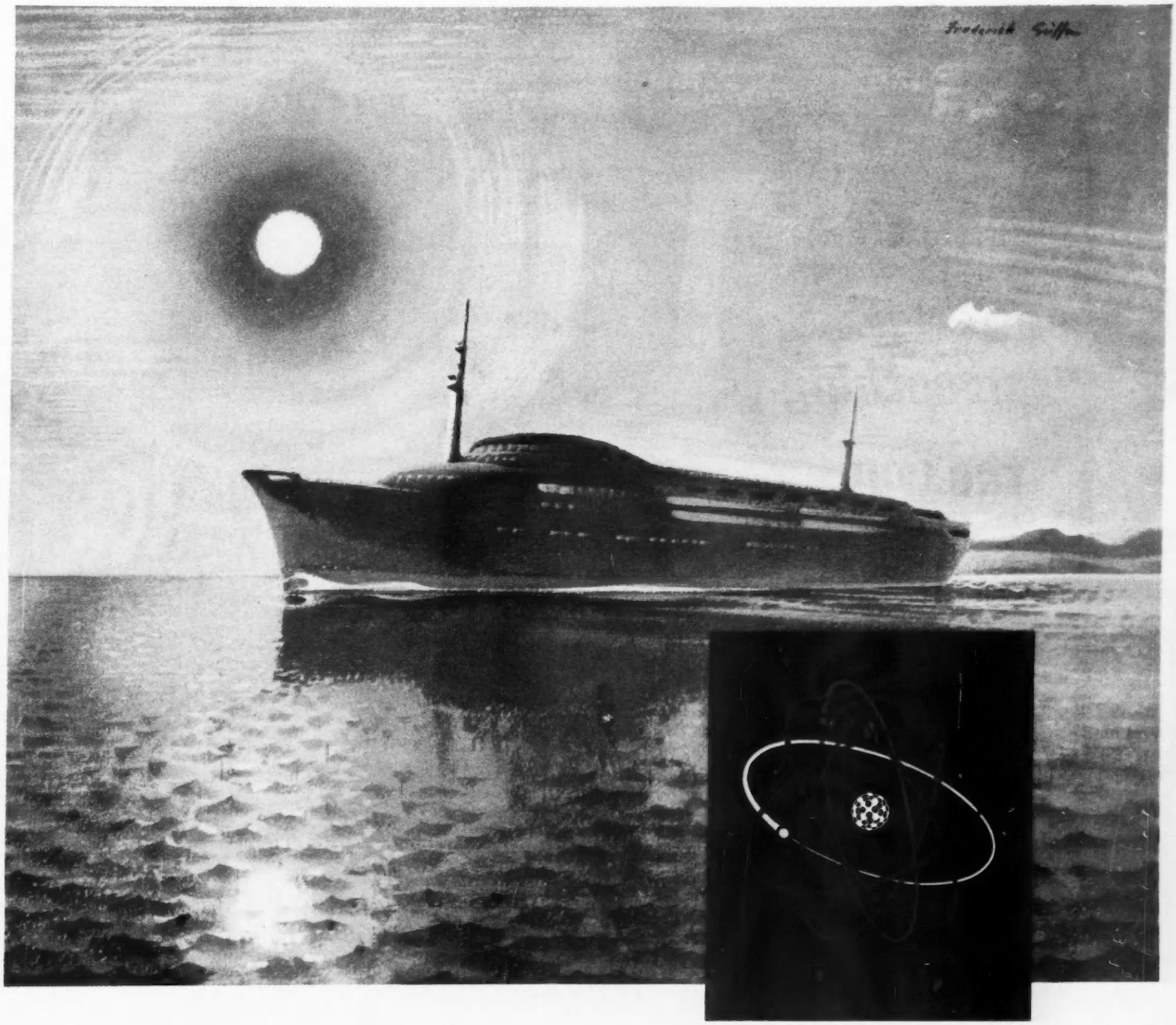

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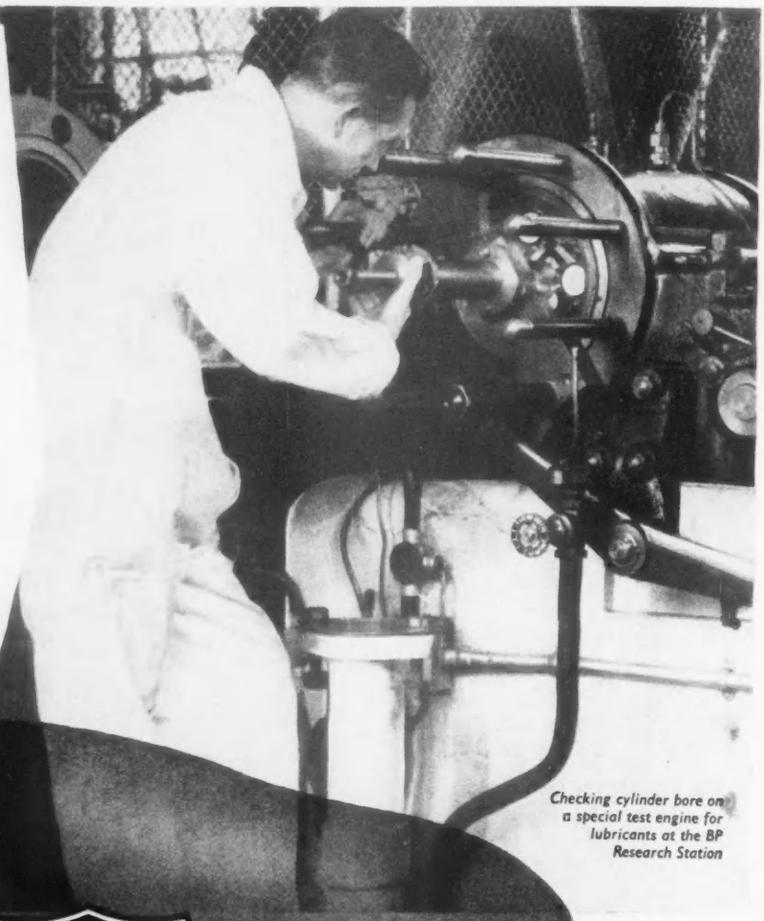

Checking cylinder bore on a special test engine for lubricants at the BP Research Station

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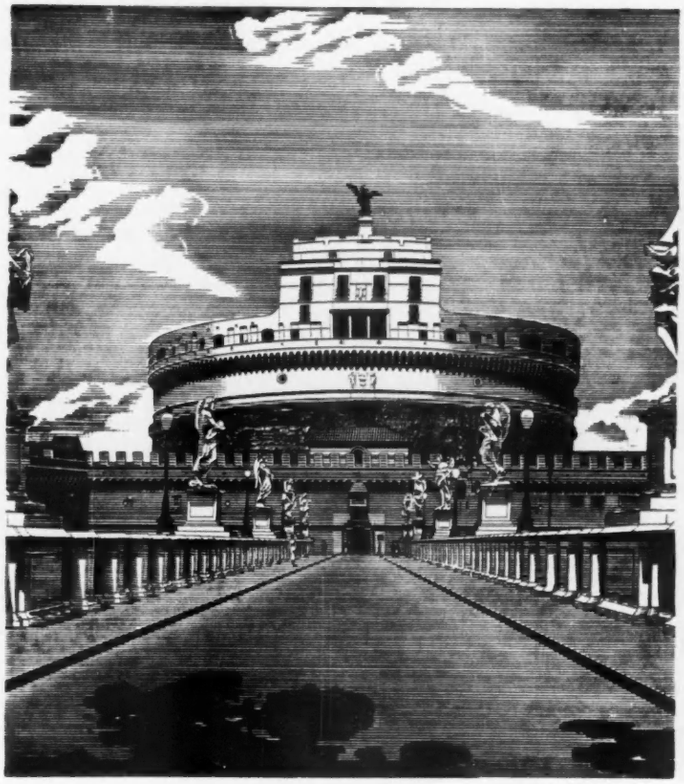

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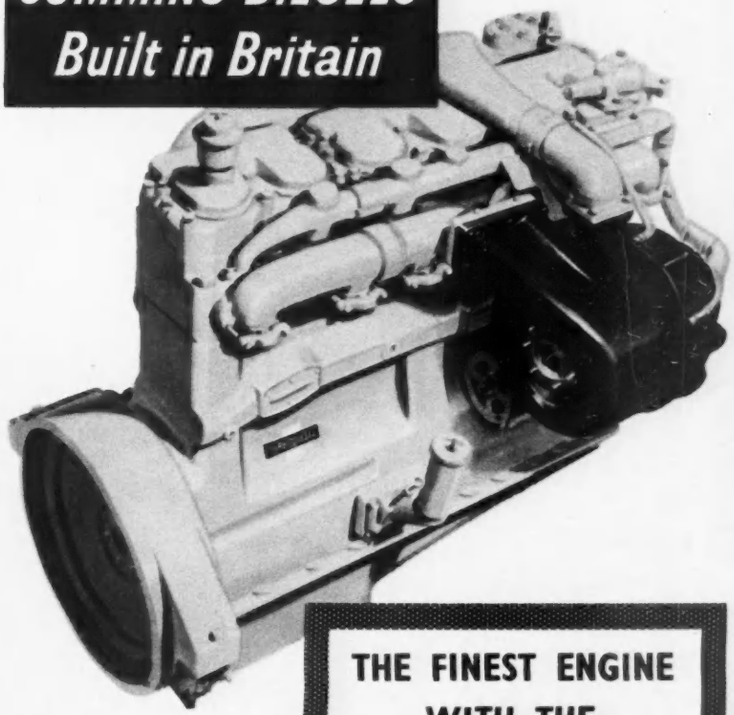

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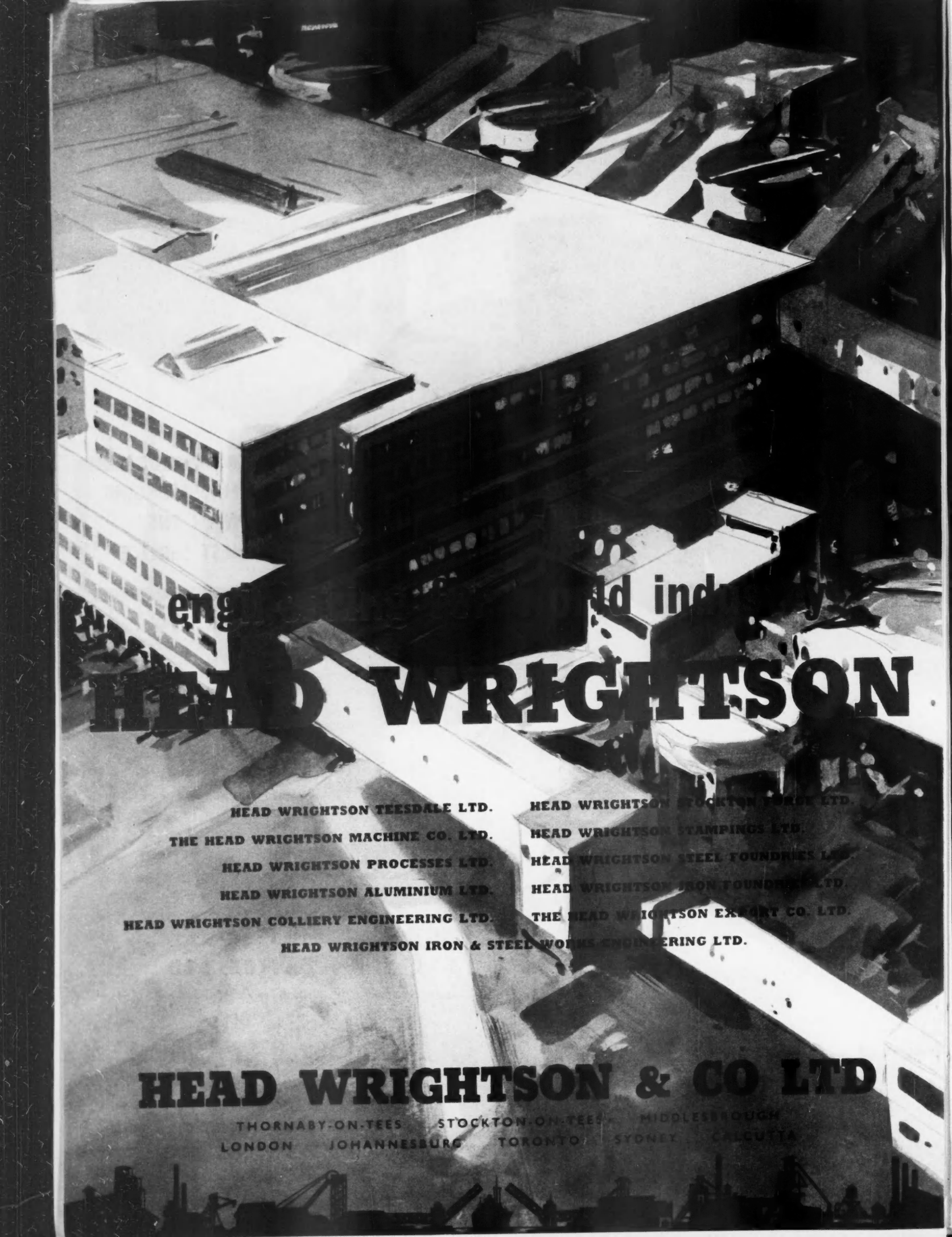

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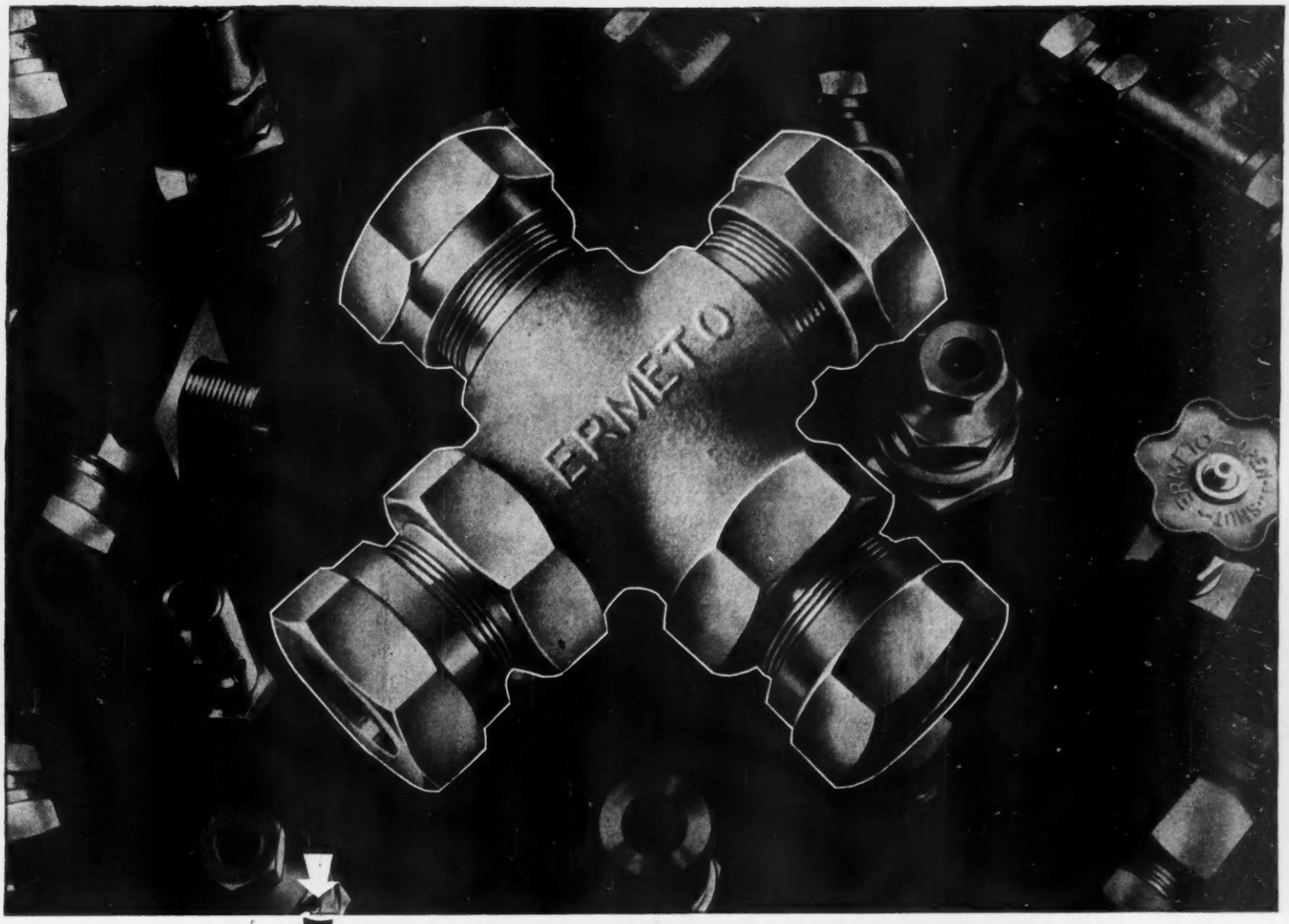

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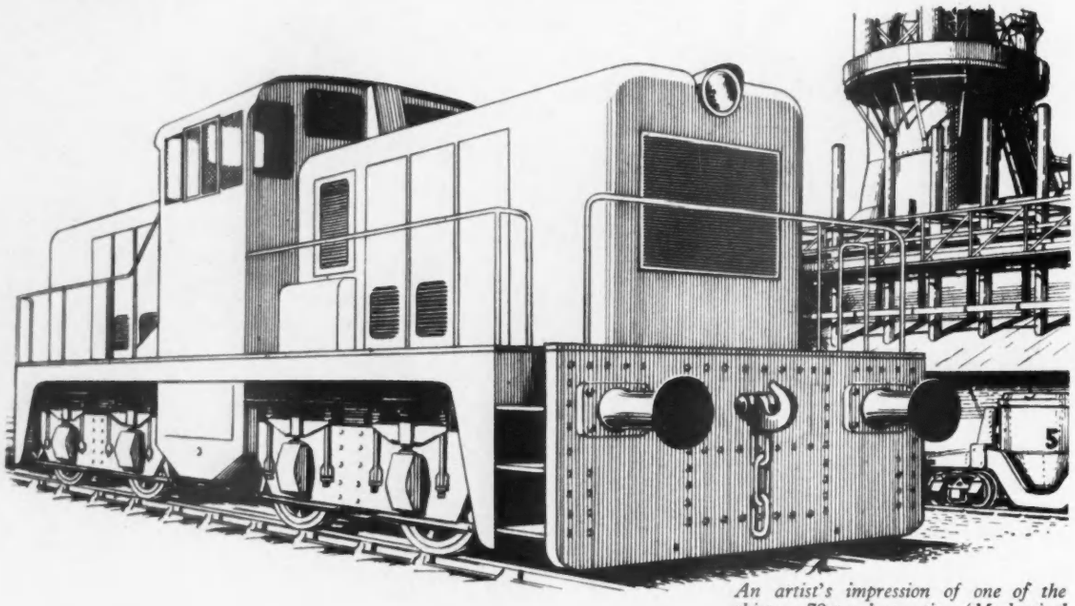
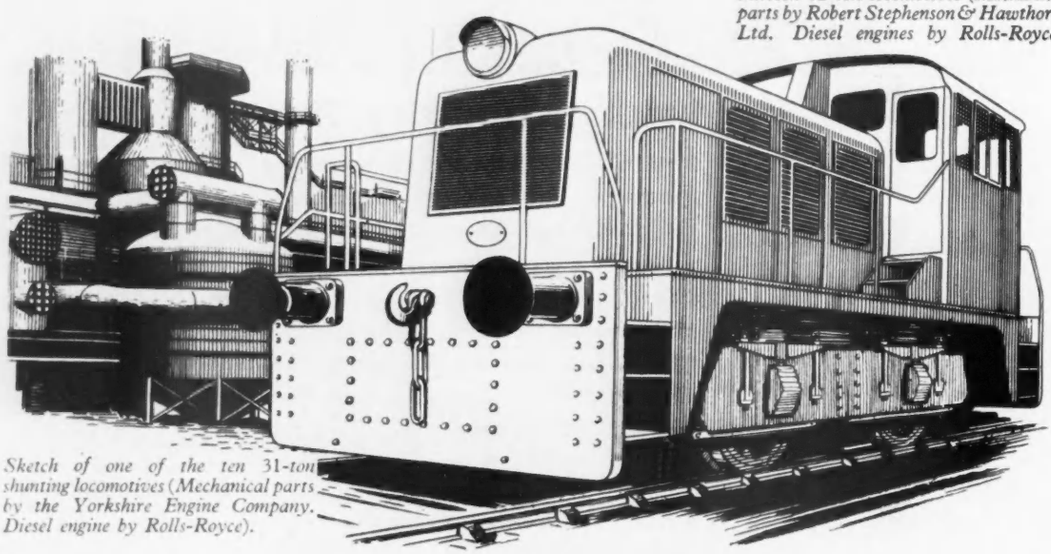


An artist's impression of one of the thirteen 72-ton locomotives (Mechanical parts by Robert Stephenson & Hawthorns Ltd. Diesel engines by Rolls-Royce).



Sketch of one of the ten 31-ton shunting locomotives (Mechanical parts by the Yorkshire Engine Company. Diesel engine by Rolls-Royce).

British Thomson-Houston, as a constituent Company of the Indian Steelworks Construction Company (ISCON), has in hand orders for a total of 23 diesel-electric locomotives for use in the Government of India's Durgapur Steelworks. The electrical equipment of the thirteen 72-ton Bo-Bo units and ten 31-ton 0-4-0 units will be of BTH design and construction throughout.

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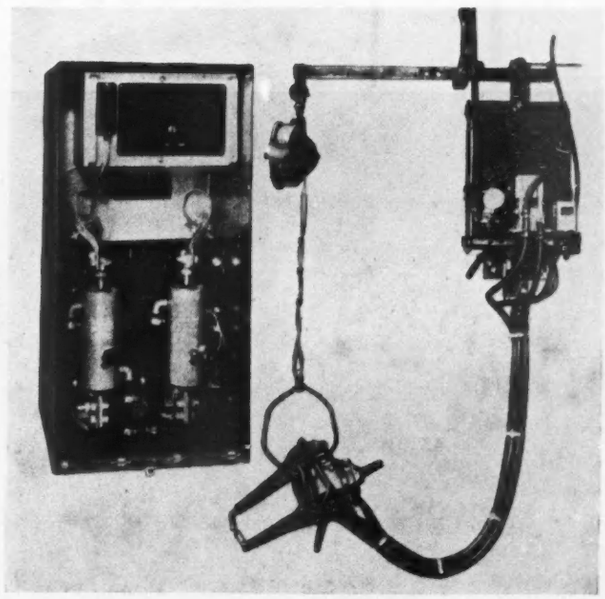

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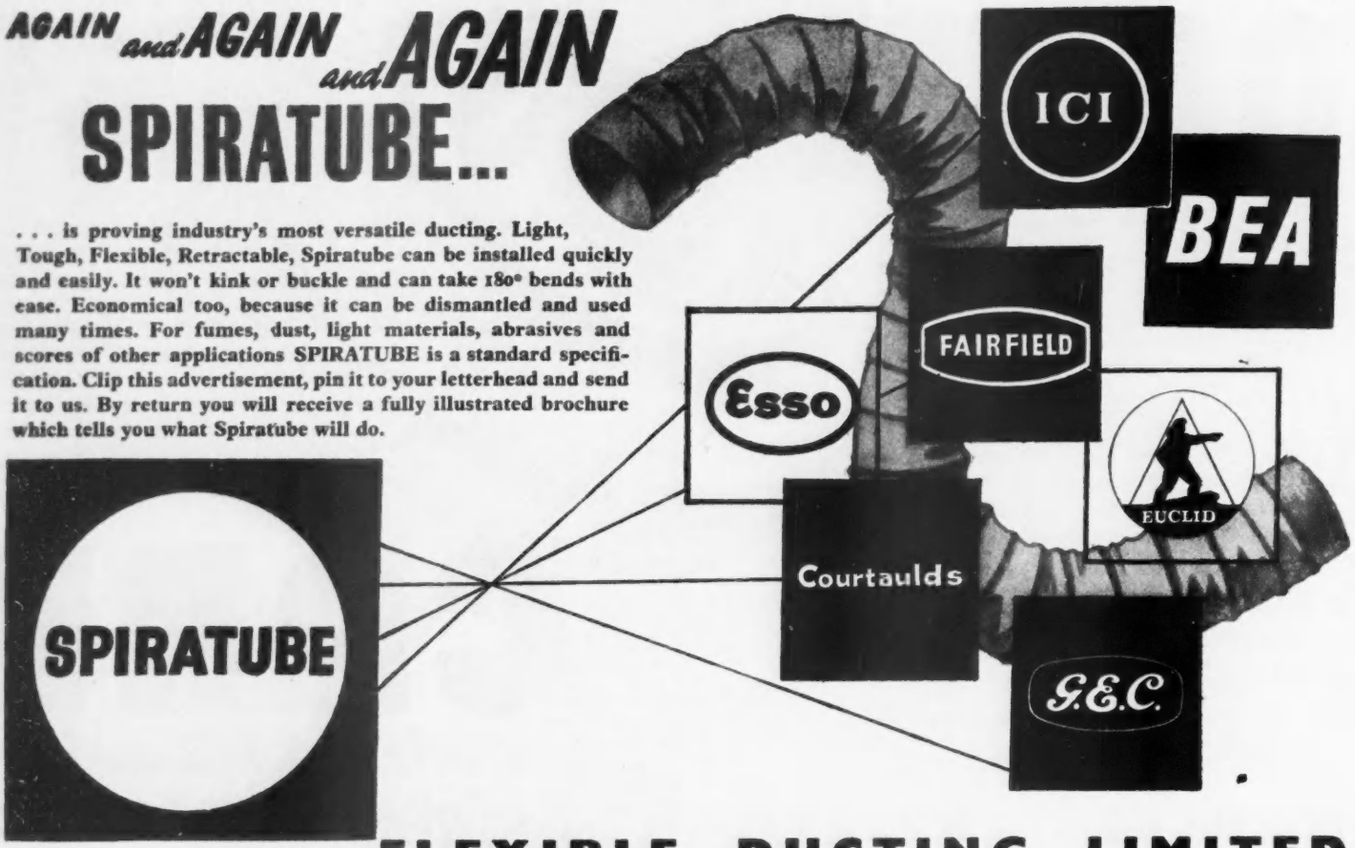

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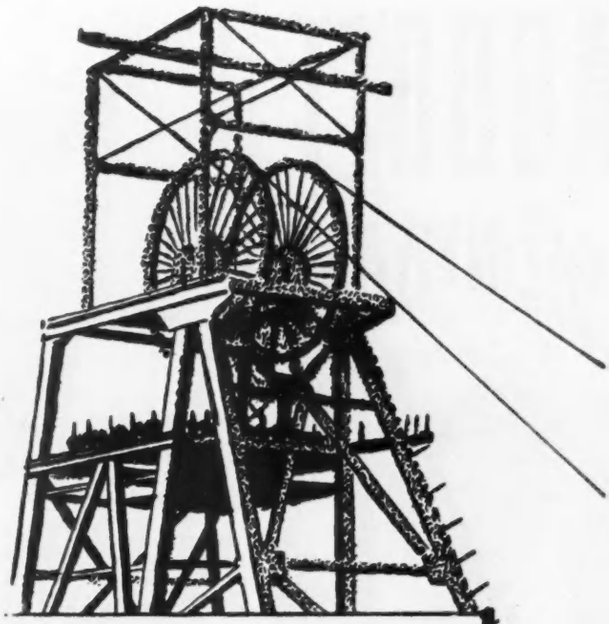

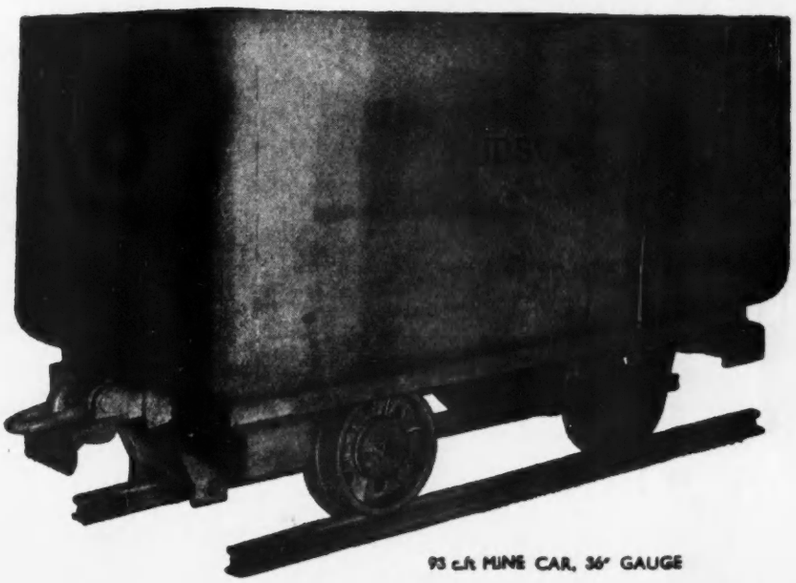

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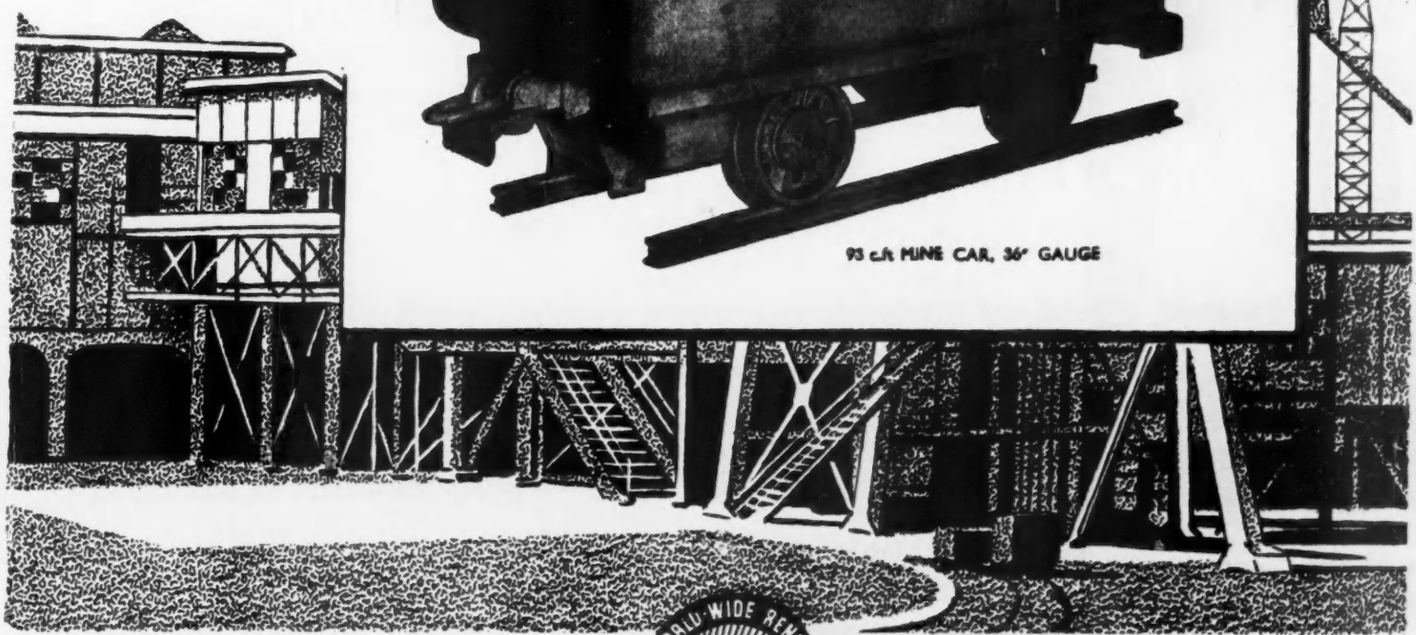

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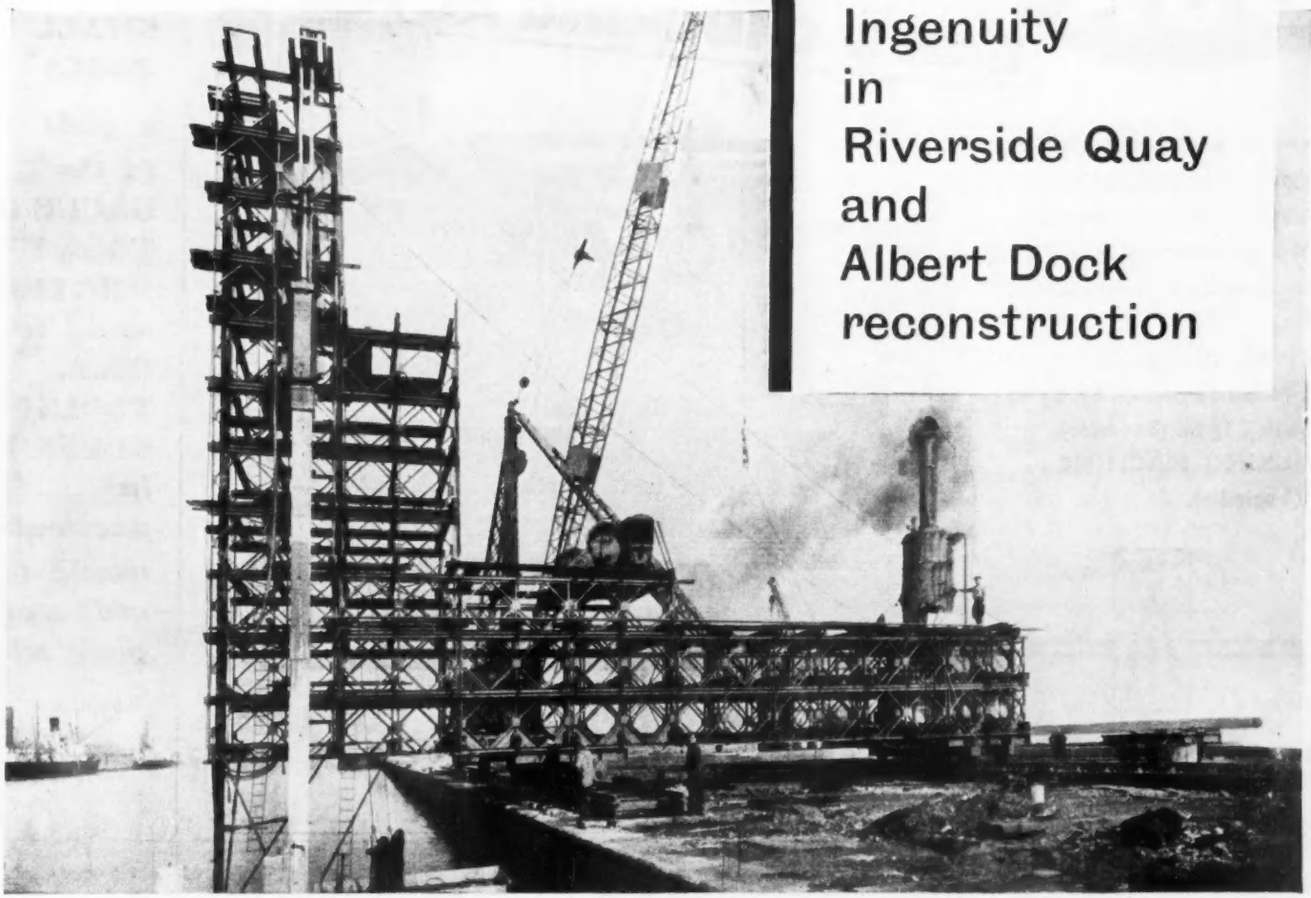

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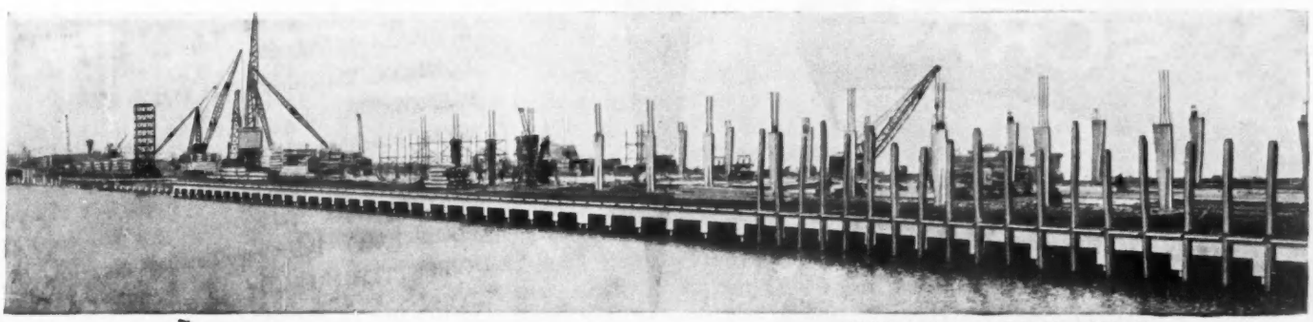

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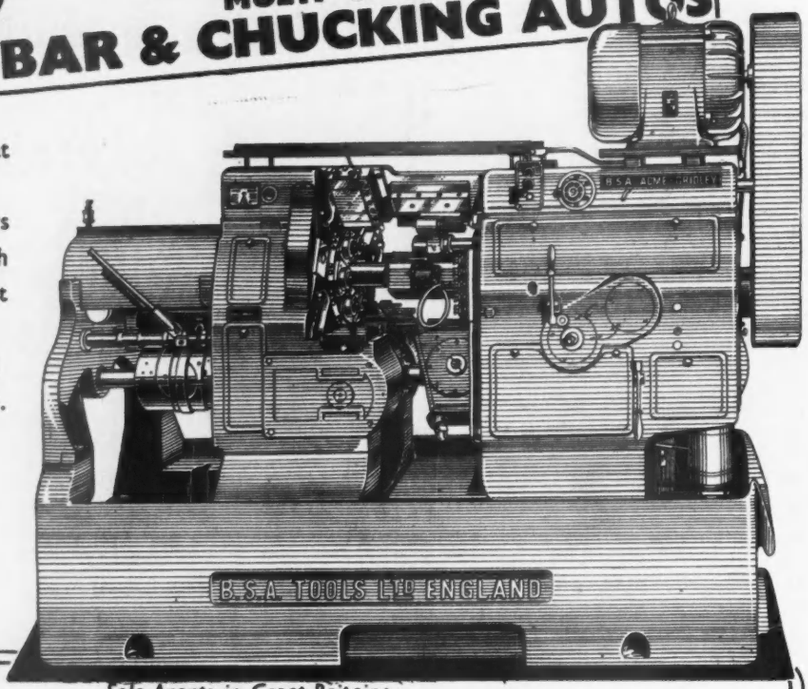

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THE ENGINEER

No. 5337 MAY 9, 1958 VOL. 205

COLLABORATION FOR NUCLEAR POWER

On page 709 of this issue we refer briefly to the signing of a long-term agreement for collaboration between the Nuclear Power Plant Company, Ltd. (N.P.P.C.) and A.G.I.P. Nucleare. It is understood that the first fruit of this agreement will be a contract to build a single-reactor 200MW nuclear power station near Latina, about 40 miles south of Rome, and that building work is likely to be started before the end of next month. Engineers will readily visualise all that is implied by the word " collaboration " in the engineering of a project such as this. The overall design is being done by the N.P.P.C., with the help of A.G.I.P. technicians to fill in the details in accordance with Italian practice, standards and regulations. The civil engineering and structural work will be undertaken by A.G.I.P. The main items of plant, including the reactor and its varied ancillary equipments, together with boiler elements and turbo-generators, are to be supplied by the N.P.P.C. group. To prepare the ground for this project there has been an exchange of teams of engineers between the two groups, with men from the N.P.P.C. acting as consultants, advisers and mentors to their Italian colleagues in the A.G.I.P. headquarters in Milan. Similarly Italian technicians have been at work in the Knutsford offices of the British consortium, learning the new techniques, and the application of older techniques, involved in building and operating a nuclear power station. At the same time A.G.I.P. Nucleare has established in Italy a new laboratory for applied research, whereby Italian technologists can gain valuable experience while carrying out *ad hoc* investigations as well as longer term studies which may be of mutual benefit to the two groups of firms.

Clearly the real significance of the recent agreement is not merely that the two consortia intend jointly to build a 200MW nuclear power station, important though that is. What matters is the declared intention of long-term collaboration and the practical steps that are being taken to make that collaboration close and effective. As far as the N.P.P.C. is concerned the potential benefits are self evident. For this consortium, like the others in Great Britain, must make determined efforts to earn some return on the very heavy expenditure already incurred in nuclear engineering development work. This they can do either by building overseas complete nuclear power stations, or by supplying components, designs, or " know-how," bearing in mind that the market for the first alternative is limited. Many of the potential customers are in countries which have some industrial background, are short of conventional sources of power and, naturally, want to learn to design and build stations using nuclear fuels. Sooner or later, with or without the help of Great Britain, these countries will acquire the necessary knowledge and experience to do the bulk of the work themselves. In such circumstances collaboration from the outset has much to commend it. What does it mean in commercial terms applied to the proposed 200MW station near Latina ? Let us suppose that the total cost will be of the order of £20,000,000. Then, as Sir Claude Gibb suggested at a recent press conference in London, rather more than half that sum (representing mainly the civil engineering work) would be spent in Italy, while the rest (representing the more advanced plant and " know-how ") would accrue to the N.P.P.C. In later projects arising from the long term agreement, as the Italians gained experience the proportions of the sums to be spent in Italy and Great Britain would, of course, vary, but the British manufacturers might be expected to contribute the more specialised work. In any event the co-operative agreement between the N.P.P.C. and A.G.I.P. should not be assessed on a narrow commercial basis. In the long term it should enable both participants to make economical use of technological manpower and both should benefit since the dissemination of knowledge is never a one-way process. The agreement, in fact, may well serve as a pattern for Great Britain's contribution to the development of nuclear power overseas.

INSTITUTE OF METALS GOLDEN JUBILEE

The Institute of Metals is celebrating its Golden Jubilee this year ; and amongst the celebrations have been a reception at Fishmongers Hall in the City of London and a Golden Jubilee banquet held on Thursday, May 1, at Grosvenor House. On that latter occasion Lord Tedder, the President of the Institute, voiced an opinion widely held by service-men—and by others—that the pressure on science to solve defence problems speeds up and benefits engineering advance in general. He referred, in providing examples, to the development of jet engines and of the atom bomb and to the " lead " held by American aircraft, as a consequence of military research effort in the U.S.A., suggesting that without the military effort civilian developments would have been less fast. But, for ourselves, we have never felt as confident upon the point as are service-men. Doubt obtrudes. For example, the needs of defence, before and during the war, led to the concentration of research effort upon the Whittle centrifugal compressor gas turbine engine. But post-war engines for the most part are fitted with axial flow compressors and work upon the development of such compressors might well have gone forward more rapidly had the defence mind (quite rightly for defence purposes) not found it more immediately profitable to encourage Whittle's work. Then, again, the needs for defence triggered off the immense expenditure which led, through the development of atom bombs, to the construction of nuclear power stations. But it appears seriously to have delayed the prosecution of researches that have led up to the building of " ZETA." The future may very possibly show that the generation of power through the fusion atomic process is economically (and in other ways) preferable to its generation by the fission of heavy atoms and therefore that the world would have better benefited if effort had been concentrated on the " ZETA " develop-

ment in the first place. Finally, in referring to the "lead" held by American aircraft, Lord Tedder must surely have been thinking only of military machines. For in civilian aircraft it is this country that appears to lead at present. Had it not been for diversion of effort to develop predominantly military aircraft it is conceivable that Britain's lead might have been even more marked for civilian aircraft !

The truth is that advances in civilian engineering practice arise only as a by-product of service researches. The ends that service-men are seeking are largely destructive, as in the development of rockets, bombs, guns and tanks ; and even when they are not destructive they often differ widely from civilian ends. The machinery of a warship, for example, is designed to operate economically for long periods at "cruising speed," but to yield much more power for a higher speed when in action. This contrasts with the merchant navy requirement for economic full-load operation whenever at sea. There are therefore limits to what can be learnt from service experience for use for civilian purposes. These limits are made all the more restrictive because the services, for obvious reasons, are secretive. Much that is discovered by service research never gets published ; and service research is hampered by the difficulty of engaging in discussion with workers in civilian establishments. It is, of course, true that an effort is made to ensure that anyone likely to benefit from a discovery will be informed about it. The services like to think that they can ensure a sufficient spread of information in that way. But no editor of a technical journal is likely to agree with them. For the very fact that the means of publishing information have expanded phenomenally within this and other countries in the last fifty years or so is in itself evidence of the difficulty of finding any other means of conveying information to all those who may have a use for it. Thus much of the virtue of service research is lost. In our Centenary Number, published just over two years ago, Sir William Stanier expressed the view that "the influence of war upon engineering advancement is to distort rather than to further it. The benefit, so very apparent in certain fields, is .... more than overbalanced by the setbacks suffered in other fields, and the wastage of talent inherent in the design of destructive instead of constructive things." The remark we believe applies as much to peacetime defence researches as to wartime research. If we could dare to spend less upon developing new weapons and more upon developing civilian products not only, we believe, would engineering knowledge be more quickly acquired, but there would be a better balance in the state of advance of knowledge in various fields.

WATER POLLUTION RESEARCH

In our issue of April 11 we commented adversely on a recommendation of the Trade Effluents Sub-Committee of the Central Advisory Water Committee that there should be an extension from 1958 to 1961 of the period during which River Boards must gain the Minister of Health's consent before they can prosecute concerns for polluting rivers in certain ways. There now lies before us, as we write, the annual report for 1957 of the Water Pollution Research Board and the report of the Director of the Laboratory. After reading it we find it less easy than ever to believe the sub-committee is acting rightly in making its recommendation. For there seems very little reason to fear that River Boards would use their powers unwisely ; substantially the reverse, in fact. The Boards, the Research Laboratory and industry are co-operating together already with the object of reducing pollution. During 1957 the Research Board appointed a committee to act as a liaison between the laboratory and industry. A number of members of that committee have been nominated by the Federation of British Industries and their function is to be to direct the attention of the laboratory to problems in which industry is especially interested. Furthermore, the Federation is to make a substantial financial contribution to the work of the laboratory. There is a clear demonstration here that industry is far less villainous than those who want to see clean rivers sometimes suppose. The more responsible firms actively desire not to pollute streams and rivers into which they discharge effluents. It is not so much the cost of treatment that deters them from installing suitable plant as the sheer difficulties of treating certain industrial effluents at all and of measuring the toxicity after treatment. They hope that the research laboratory will be able to help to solve such problems, problems that industry has for some years actively been studying for itself. On the other hand the laboratory is hoping to set up a similar committee, including members nominated by the River Boards Association. This committee will draw attention to the problems of particular interest to River Boards. Usually, it may be supposed industry and River Boards are likely to be interested in much the same problems. But there may well exist sometimes a difference in the emphasis assigned. Quietly and in the background we can foresee the laboratory playing a part educating industry, on the one hand, and the Boards, on the other, to see each the other's point of view. One other point may be noted. The River Boards have been hampered in drawing up by-laws by the difficulty of drawing up a general test of toxicity. It is partly on the excuse that such by-laws have not been drawn up that the Trade Effluents Sub-Committee made its recommendation. But that section of the report which describes the work being done at the laboratory by a team from the Ministry of Agriculture, Fisheries and Food, towards devising such a general test is not particularly encouraging. It is true that an apparatus has been devised, but it is still doubtful how suitable it will prove to be, partly because it measures the sensitivity to pollution of a species of fish not native to these islands. Additionally, one wants to be certain that though an effluent may be non-toxic to fish, it is also non-toxic to the food of fish. It is just thirty years since the Water Pollution Research Board was set up. A perusal of this report shows how valuable its work has become ; and how extensive, too ! May it lead eventually (as well it may) to the placing on the Statute Book of an Act for maintaining the waters in Britain's rivers clean, comparable in scope to the Clean Air Act of 1957.

AGRICULTURAL ENGINEERING

On Monday, the president of the Agricultural Engineers Association, Mr. Lionel Harper, made some interesting observations on the present state of that section of the engineering industry for which he is so well qualified to speak. He was a guest at the annual luncheon of the Institution of British Agricultural Engineers, and in proposing the principal toast, emphasised the fact that, over the past five years, ten leading British agricultural engineering firms have spent no less than £13,000,000 in development work of one kind and another. At first glance, that may not appear to be a vast expenditure on capital account when compared with the investments of some other sections of the engineering industry. But it is a factor that is worthy of consideration. For it indicates

very clearly that agricultural engineering in this country continues to make an increasingly valuable contribution to the raising of the standard of living all over the world. A large percentage of the agricultural machinery industry's production is exported ; much of it to the under-developed countries of the world. Mr. Harper mentioned only the combined capital investment of "ten leading firms." He did not intentionally overlook the efforts that are being made by the many smaller agricultural engineering concerns ; their combined capital expenditure might not be computable in millions of pounds, but their contribution to the whole is none the less worthwhile.

We were glad, however, to listen to Mr. Harper's subsequent remarks. It was permissible, he said, to be proud and even "cocky" about what an industry has done, but "it is where it is going that really counts." Agricultural engineers, and engineers generally, must set their sights high. In their calling, there is always a place for vigilance, imagination, farsightedness and originality. None who are engaged in any branch of the profession and business of engineering will deny it. Fresh fields are continually being conquered. Mr. Harper, it is true, was talking to a company of specialists whose primary concern is with providing machines that will help along the important task of food production all over the world. The "challenge" that he offered, however, that British engineering must lead, and never be content to follow, is one which must always be kept in mind by all the sections of that great industry for which we are able to speak.

SANDWICH COURSE FINANCE

Two things deserve particular notice about the statements issued by the Ministry of Education and the Federation of British Industries last week, and reported in our last issue. First, there is strong evidence that industry approves of the product of sandwich courses leading to the new Diploma in Technology and Higher National Diploma. For rapid progress is being made towards reaching the objective of an output of some 5000 men so trained per year and a substantial proportion of the students are having their fees paid by industrial firms. Secondly, there is evidence that there are and will continue to be, some firms which feel unable to meet the whole cost of a student's training and at the same time evidence that some local education authorities have been interpreting the powers assigned them to make grants to students in ways that bear hardly on him or on the firm which desires in some degree to support him. A memorandum to Local Education Authorities from the Ministry is intended to clear the situation up. It appears to us that in issuing the memorandum, which makes the situation substantially more favourable for students unsupported or partly supported by firms to receive local education authority grants, the Ministry has had in mind the belief of the Grand Council of the Federation that industry "by enabling selected employees to pursue advanced sandwich courses, in addition to supporting day release schemes, acts in its own as well as in the nation's interest," and the recommendation of that Council that "firms which already pay their students' fees and salaries should continue to do so," now and in the future. In our view it will be well worth while for firms to do so. For thereby, as the F.B.I. statement puts the point, "it stimulates the students' sense of loyalty to the firm and strengthens the firm's ties with the college." Fears amongst education authorities that industry will try to transfer the cost to them will, we think, prove quite unfounded.

THE CHANNEL TUNNEL

Hot after the announcement of agreement between the Egyptian Government and the Suez Canal Company about the compensation to be paid to the company for the nationalisation of the canal, there follows the news that a Channel Tunnel Study Group has signed contracts with three economic research organisations to begin surveys more detailed than any yet carried out, of the prospects and feasibility of a tunnel for a railway or a roadway or both under the Channel. It will be recalled that last year the group, to which reference is made above, was set up by agreement between the several concerns, the British Channel Tunnel Company, the French Channel Tunnel Company, the International Road Federation, the Suez Canal Company and Technical Studies Inc., the last an American group. The interest of the Suez Canal Company is believed to be 30 per cent. Economic research contracts have now been signed with the Economist Intelligence Unit, the Societé d'Etudes de Techniques et Economiques of Paris and De Leuw Cutter and Co., of Chicago. Geological and geographical surveys are also to be made and the shafts and galleries on both sides of the Channel, driven some seventy years ago when, for a time, it looked as though this more than hundred-year-old project would be constructed, are, it is reported, to be cleared for geological examination. It really looks, in fact, as if within a year or two an attempt will be made to raise money towards the construction of the tunnel estimated to cost at least £75,000,000. Who would have thought, when finance towards the cost of building the high dam at Aswan, in Egypt, was refused to Colonel Nasser—who forthwith nationalised the Suez Canal—that the outcome might be the construction of a tunnel under the English Channel?

The Engineer — 100 Years Ago (MAY 7, 1858)

"MASTERS AND MEN."

"The unwearied Mr. Mackinnon has been again drawing the attention of the House of Commons to the report of the select committee of 1856, appointed to inquire into the expediency of establishing equitable tribunals for the amicable adjustment of differences between masters and operatives, and moved for leave to bring in a bill to enable masters and workmen to form councils of conciliation and arbitration. The hon. member observed that, under the present law, the magistrates were called upon to decide questions about which they knew nothing, and their inclination was generally to support the master. He was the chairman of the committee by whom the subject had been investigated in 1856, and all the operatives examined by that committee were in favour of the establishment of councils of conciliation. Mr. Walpole having expressed his opinion that facilities might well be offered for referring to arbitration disputes between masters and workmen, leave was given to bring in the bill."

"FOREIGN JOTTINGS"

"The Palace of the Tuileries is about to undergo a complete repair. The works will last until the winter, and it is thought that, in the meantime, the Emperor and Empress will take possession of the Palace of the Elysee.—The imperial steam yacht Aigle, which is building in the port of Cherbourg, will be 258 feet long. She is to be a paddle steamer of 500-horse power. It is said that the Aigle will be a model of naval architecture.—Russia has consented to the construction of three lines of railway between the Black Sea and the Caspian, all three starting from Tiflis."

INTERNATIONAL & UNIVERSAL EXHIBITION —BRUSSELS 1958

No. IV—(*Continued from page* 649, *May* 2)

DURING the last century, thirty World Exhibitions have been held, beginning with the Great Exhibition in London in 1851. Thirty-four years later came Belgium's turn with Exhibitions in Antwerp (1885, 1894 and 1930), Liège (1905 and 1930), Ghent (1913) and Brussels (1888, 1897, 1910 and 1935). The last fair to be held was the New York World Exhibition of 1939. After an interval of 19 years, the 31st International and Universal Exhibition opened in Brussels on April 17, and will remain open to visitors from all over the world until October 19. Sited on an area of 200 hectares—one-third the size of Brussels and 1½ times that of Hyde Park—the Exhibition is an event which according to the 1928 Agreement cannot be repeated in Europe for at least six years. Our article describes the fair, in which Great Britain is taking a prominent part. The general theme is "A Balance Sheet for a More Human World," and besides the Belgian and Foreign Sections, there is for the first time an International Section representing the important international bodies which have come so much to the fore in recent years. The accompanying illustration shows the suspension foot bridge in the German exhibition: the girder seen is stressed in compression, bending, and torsion, the deck being cantilevered from it.

United States

ONE of the more unusual presentations by the United States in the Brussels World Exposition this year is a series of motion picture programmes in the form of " Circarama." The equipment for projecting the 360 deg. motion pictures is a development of the Walt Disney Studios in Hollywood. The device consists of eleven synchronised cinematograph cameras arranged in such a way that their lenses are able to photograph all of the objects surrounding the cameras at the same angle and with the same focus. The films taken from each camera are placed in a series of eleven synchronised projectors which are set around the outside of the circular screen to provide rear projection.

Thus the viewers standing within the circle are surrounded by an uninterrupted panoramic scene in a complete circle of 360 deg. The films are in colour and represent many striking scenes of the United States great cities, farms, transport arteries and other subjects of the United States and its people.

The predominant display elements in the United States Pavilion show salient aspects of life in the United States. They relate chiefly to habits of Americans in their home surroundings, furnishings, equipment and, in a larger sense, by architecture, community development and industrial design. Other exhibits are concerned with the cultural interests among children and with American fine arts in different categories.

The " Face of America " exhibit occupies one-third of the main floor at the entrance to the pavilion, and presents a series of varied impressions characteristic of the United States—ethnical, geographical, historical and political. Examples of natural or man-made objects from every section are on display, keyed to a 100ft long outline map of the United States suspended overhead. Among the objects shown are a 1903 Ford automobile, a slab of a giant redwood tree, tumbleweed, Indian moccasins, mail order catalogues, and an innumerable miscellany of Americana.

In the map room a series of maps of the United States are on view, supplemented by mural photographs. They include numerous road maps of the most popular cross-country routes. The U.S. Coast and Geodetic Survey has provided a section of aeronautical maps. There are also maps which relate to population trends and the location of ethnic groups, and special agriculture, transportation and topographical maps of the continental United States.

An exhibit illustrating city planning and urban development in the City of Philadelphia is situated on the main floor of the pavilion. The scale model of the city before and after its completed community improvement programme includes 45,000 model buildings, 25,000 cars and buses, and 12,000 trees. Movable parts show how the city is widening streets and highways and how new buildings are replacing old and obsolete structures.

A companion exhibit to the ' city improvement " exhibit is one showing how the creation of " industrial parks " in many parts of America has, by planning and landscaping, made factory districts clean, healthy and imposing components of urban and suburban regions in America.

The role that automation plays in the scientific, industrial, business and cultural aspects of American life is demonstrated in another main floor exhibit. This shows automation creating greater material abundance and greater leisure for individual creative and recreational pursuits. The exhibit also demonstrates how automation means a new approach in the factory, in the office, and in the laboratory, to more efficient and more productive methods. An example on display is the use of automation by the New York Stock Exchange.

On central display is also the giant " Ramac " computer system, which has been set up to answer questions of visitors on specific subjects in ten languages.

Colour television plays a predominant role as a scientific as well as a cultural demonstration. A colour TV studio broadcasts regular programmes, which can be viewed in " living colour " on the TV receivers situated at vantage points. The studio area in the pavilion allows an audience of 400 to watch the actual equipment and technical procedures used in transmitting colour TV. A demonstration of this scope and duration is stated to be the first in Europe.

A special music room has been established on the ground floor of the pavilion as an exhibit of the latest in high-fidelity and binaural sound equipment and there is a recreational and rest area where visitors may hear the best in classical, contemporary and jazz recordings.

The International Geophysical Year exhibit primarily describes the extensive scientific research going on in Antarctica and the role of the United States generally in co-operating and sharing scientific information with other nations exploring global weather phenomena and the mysteries of outer space. Scale models, photographs, charts and a running commentary further define the research undertaken in eleven major departments of geophysics.

The nuclear energy exhibit illustrates the various developments in this field of the peaceful uses of atomic energy, the use of nuclear fuels and the commitments of the United States in sharing the benefits of atomic energy research with all nations.

Photographic scenes of the United States, typifying not only areas of the country but significant groups of people, architecture, memorials and scenic beauties are displayed on a large device called the " Photo Tower." This is constructed of three huge cubes piled one upon the other in irregular fashion. The tower stands 42ft high. The photographs it holds represent the work of a number of outstanding photographers of the United States.

One of the largest single issues ever published of an American newspaper is displayed on the main floor. This is the *New York Times* of Sunday, November 24, 1957, containing 480 pages, which is presented page-by-page on a special decorative plywood stand. Six voting machines have been installed on the two floors of the United States pavilion to underline America's system of free elections. The machines are electrically operated and register total numbers of votes as in a modern " automated " adding machine.

On the balcony of the pavilion is an extensive exhibit called " Islands for Living," which suggests to visitors the characteristic living habits of Americans as reflected in their home surroundings—kitchen, living area, bathrooms, children's playroom, patio and garden. All areas are fully equipped and furnished with the variety of consumer goods that generally make the American home so distinctive. These utensils and other equipment also serve as examples of present-day American industrial design.

By contrast with the traditional method of displaying photographs on flat surfaces or within frames, the " Cityscape " exhibit uses in conical form some striking panoramic illustrations of four great American cities—New York, Chicago, San Francisco and Dallas. The conical shapes are 6ft in diameter, thereby providing a broad sweep for the photographic mountings.

" Streetscape " occupies approximately one-third of the balcony. A 140ft long American street, complete in every detail, is lined with a number of typical shop windows illustrating the wide variety of consumer articles available to Americans, and providing a means of grouping small objects which otherwise could not be effectively displayed in the huge pavilion. The " Streetscape " also includes a news stand displaying typical newspapers and periodicals, and a drug store with an operating soda fountain.

Another major area on the balcony is " for children only " of all nations of the ages four to twelve. It is designed to encourage the youngster's creative abilities. The imagination and spontaneous inventiveness of children are given free play in the Centre. No adults have access to it, but may observe from the outside. Specially-trained teachers are on hand to supervise the children's activities.

An exhibit of domestic and industrial architecture embraces scale models and photographs of individual buildings, institutions, schools, shopping centres and dwellings, all serving to show the diverse designs and styles to be found in architecture throughout the United States.

U.S.S.R.

On entering the U.S.S.R. pavilion the first group of exhibits is concerned with machine tools for precision and mass production, with particular emphasis on ball and roller bearing manufacture. The largest of the high-production machines is a multi-spindle vertical lathe tooled for the turning of stepped shafts. This machine incorporated a gauging fixture for the finished shafts which are automatically transferred from the unloading station by a mechanical pick-up arm into the fixture. Any out-of-gauge discrepancy determined by the fixture automatically stops the spindle concerned and indicates the dimension at fault. The same pick-up arm is also used for automatically loading a blank into the machine from a feed conveyor and for discharging finished work into a transfer chute.

Adjoining this machine there is a pair of profiling lathes, each of which is arranged to turn one-half of a shaft. Unlike the usual procedure, these lathes are set face to face and not in line. The machine for the first operation has at its rear an indexing loading conveyor which picks up blanks from a transfer conveyor and loads them between the centres. When this machine has turned its part of the shaft the shaft is picked up by a centrally disposed swinging transfer arm and moved across between the centres of the second machine for the other half to be turned.

Magnetic tape control and punched card control equipment is shown as applied to milling machines, boring machines and a lathe. The other machine tools in the section include various sizes of jig borers and gear cutters and grinders. Gauging machines for taper bearings showed high-speed sizing methods for selective assembly and there is an interesting optical inspection machine for checking the surface finish of ball bearings at high speeds. The centrepiece of a display of ball and roller bearings is a large tapered bearing for a rolling mill, and this bearing, stated to weigh some 3 tons, will be seen to be very similar to the one weighing 3½ tons in the British pavilion.

Beyond these machine tool exhibits there are some large-scale models of hydro-electric schemes and a refinery. In another part there is a model of a tunnelling machine, fitted with multi-cutting heads, which are mounted in front of the shield. The spoil is discharged rearwards from the head on to a belt conveyor loading into trains of skip wagons in which it is transported out of the working.

France

The site of the French section is in the centre of an area bounded to the north by the Avenue des Nations and the footbridge, and to the south by the Avenue de l'Europe. It is surrounded by wooded heights and lies close to the pavilions of Morocco, Tunisia and Austria. The section extends over 25,000 square metres (62 acres), an area which is only equalled by the United States, the Netherlands and the U.S.S.R.

Tramlines originally cut right across the site. These now run through a newly constructed tunnel and the site has had to be filled in and levelled. The need for speed in assembling and dismantling the pavilion and of reducing the foundation supports to a minimum has lead to the choice of a special metal structure, the design of which was briefly outlined on Plate III of our issue of April 18. We hope to return to a detailed description of the very ingenious building in a later article. The main pavilion is flanked by the entrance hall, which includes the City of Paris Pavilion and the Exhibition restaurant. The surrounding grounds are laid out as gardens.

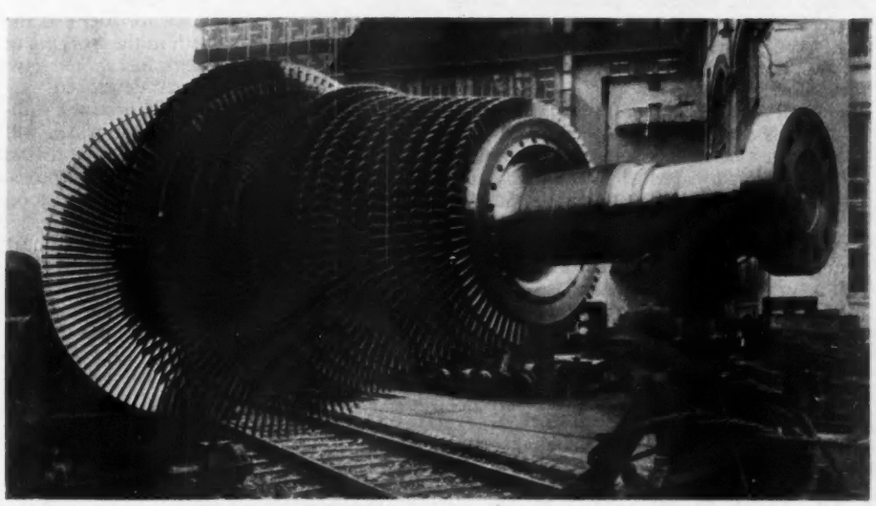
The area of ground roofed over by the main pavilion amounts to 12,000 square metres. Inside are five floor levels with an aggregate exhibition area of 25,000 square metres.

Owing to delays in its completion, the main French pavilion was not yet open to the public at the time of our visit last week. We must therefore, with much regret, defer to a later occasion the description of what is likely to be a most outstanding exhibition.

Switzerland

As in most of the other pavilions, the industrial exhibits in the Swiss section are designed to be representative of their kind, and they were selected by the Société Suisse des Constructeurs de Machines, Zurich. In the main, the exhibits are generally familiar to all in the engineering industry, and they include examples of well-known machine tools, oil engines, optical instruments, textile machines and an automatic packing machine for granular materials. One of the largest of the exhibits in the section is the complete rotor of the intermediate- and low-pressure section of a 110MW turbine built for a working pressure of 1810 lb per square inch and a speed of 3000 r.p.m. This rotor (illustrated below) has stainless steel blades and the body was built up by welding from cylindrical forgings.

The section of Switzerland covers some 11,083 square yards, and is made up of a number of small hexagonal pavilions set



Rotor of the intermediate- and low-pressure cylinders of a steam turbine rated at 110MW, 1810 p.s.i.a., 1005 deg. Fah., 3000 r.p.m., which will later be erected at the CETEC power station at Farciennes, Belgium

together around a pathway that, in its twin, encircled a large pond of some 7620 square feet. Each component pavilion is a low, ground floor only structure, with opposite walls at a distance of about 40ft (12m). The pavilion units are standardised buildings, each with a sloping two-sided wooden roof and coloured roofing material. With a steel framework, and aluminium and glass sides, they capture a maximum of light. Some of them, moreover, are open on one side, the vertical walls having been suppressed. This was done in order to give a fuller view of an element of the section that is typically reminiscent of Swiss scenery at its best : a waterfall has been contrived in a wooded part of the grounds.

Each individual pavilion is dedicated to a specific branch of activity typical of Switzerland, but the production of machines and machine tools, being of special importance and great scope, is shown in a group of pavilions.

International Organisations

It is appropriate that the many international organisations concerned with cultural, commercial and technical progress throughout the world should have a place at the exhibition. The oldest of them, the International Committee of the Red Cross, has a record of service among people of all nations which goes back nearly a century. In its pavilion at Brussels, the numerous activities of this organisation are effectively portrayed.

Then, too, there are displays by organisations which have come into being in more recent years. Examples of these are UNESCO and other specialised bodies associated with the United Nations, the Organisation for European Economic Co-operation, Benelux, the Customs Co-operation Council and the European Coal and Steel Community. The European Coal and Steel Community's pavilion is an impressive one, providing a display which is representative of the activities of the six member-states, and which describes effectively the organisation and operation of the Community.

Statistics of the Exhibition

It may be of interest here to note some of the figures relating to the Brussels International and Universal Exhibition.

Finance.—The budget of the Commissariat General and of the Exhibition Company amounted, in round figures, to 2000 million Belgian francs, while the investments by the Government in connection with the exhibition, i.e. in the building of the ring roads, tunnels, the improvement of roads in general, the Albertine Library, and other items, amounted to 8000 million francs. The value of the halls and pavilions, together with their interiors and fittings, is being put at another 8000 million francs, while the objects in the International Halls of Arts and of Science are valued at 2000 million and 1000 million francs, respectively. Equipment and other material for the exhibition thoroughfares cost a further 45,000,000 francs.

We have already mentioned that the total area covered by the exhibition is approximately 500 acres. Construction work involved the moving of over 1,000,000 cubic yards of earth. Up to 12,000 workers were employed and 60,000,000 man-hours were worked.

The combined area of buildings and pavilions is of the order of 1,200,000 square yards, the weight of steel in the frames of the buildings totals 30,000 tons, and 4½ miles of fencing and enclosures were required.

There are over 15 miles of roads and paths in the exhibition, which required hard surfacing over about 240,000 square yards, involving 25,000 tons of asphalt and 150,000 tons of road metal. About 750,000 yards of kerbs and guttering was required, and during some peak periods 200 lorries worked for more than sixteen hours a day.

The car parks of the exhibition total approximately 250 acres and can accommodate 3500 cars and 2000 coaches. There are seventy restaurants capable of serving 25,000 people at one sitting.

Over 35,000 cold-cathode and 10,000 hot-cathode fluorescent tubes have been installed, as well as several hundred mercury-vapour lamps. The total installed capacity is stated to be over 60MW, four times as much as the exhibition of 1935.

Cultural Events

Two exhibitions, each of three months' duration, are to be held in the International Palace of Art. The first is devoted to contemporary art ; the second will portray mankind in relation to the visual arts throughout the ages. Britain is represented on the International Committee which was responsible for arranging these two shows. For the exhibition of contemporary art this country has been asked to provide about sixteen exhibits, a satisfactory contribution considering that the total comprises about 200 artists from thirty nations.

National Days.—Each country has been given a day or series of days in which special emphasis can be laid on national performances, Great Britain having been allocated July 10, 11 and 12 as her National Days. On these days performances of British works will be given in the Grand Auditorium at the Exhibition, as well as military band and open-air concerts on the Esplanade and elsewhere, including a floodlit performance in the " Grand' Place " in Brussels. Other scheduled items include symphony concerts in Brussels and elsewhere in Belgium, and a week's programme of ballet at Brussels, while the Old Vic company is to take part in the Antwerp festival in July and later give performances in the capital.

(To be continued)

Metallurgical Aspects of Nuclear Power Engineering

By J. C. WRIGHT, Ph.D., B.Sc. (Eng.), A.I.M., A.M.Inst.F., A.C.T., Birm. *

No. III—(*Continued from page* 660, *May* 2)

The basic metallurgy associated with nuclear power reactors is described in this article, both for the British emphasis on gas-cooled reactors and the American trend towards liquid cooled reactors. The physical metallurgy of the fissile fuel metals, uranium, plutonium and thorium is described in sufficient detail for the interesting behaviour of these materials under reactor conditions, particularly irradiation and corrosion, to be appreciated. Possible explanations of the mechanisms of these unusual effects are reviewed. Methods of developing fuel elements, with a view to minimising difficulties experienced in reactor operation, are then briefly reviewed. This field covers the use of alloys of the fissile metals, present and possible future methods of canning fuel elements and the increasing interest in ceramic and cermet fuels. Development of certain non-fissile metals and alloys for use in reactor construction has been rapid. These developments are outlined and the effects of irradiation and dry, wet and liquid-metal corrosion, on the properties of non-fissile materials are discussed. The applications of physical metallurgy to reactor development are emphasised but, where appropriate, the production techniques for some of the special materials are introduced.

Present and Possible Future Developments in Nuclear Fuel Elements

BEFORE reviewing present and possible future trends in the development of reactor fuels it is advisable to consider the ideal properties required of a reactor fuel and the special difficulties met with in the working of a reactor. Ideally, a reactor fuel should have the following properties well developed.

(i) During fission it should produce sufficient neutrons in excess of those which will be absorbed uselessly to continue the fission process with a margin for control purposes. In other words the fuel should have good neutron economy.

(ii) The fission process produces heat throughout the whole volume of a fuel element and, to be useful, this heat must be transferred to a medium which is capable, after a further heat exchange, of passing the energy to a turbine generator set. The fuel element must therefore contribute to good heat transfer without reacting with the coolant.

(iii) The fuel element must be able to prevent release of fission products, which could be very radioactive, to the coolant circuit.

(iv) Probably the most difficult property to achieve satisfactorily at present, and the one associated with the physical metallurgy of a fuel element to the greatest extent, is that the fuel should be capable of a high burn-up without mechanical failure.

Most of the special difficulties met with in the reactor directly concern this last property. Summarising the difficulties there is the possibility of damage due to:—

(i) Phase changes and transformation damage.

(ii) Surface roughening and growth due to thermal cycling.

(iii) Wrinkling and growth due to irradiation effects.

(iv) Swelling due to irradiation effects above 450 deg. Cent.

(v) Changes in mechanical properties.

(vi) Changes in physical properties.

Although the above factors mainly concern the control of mechanical failure, the other properties of a reactor fuel may well be affected when attempts are made to overcome mechanical failures. For instance, alloying elements must be chosen with due regard to neutron absorption cross section or the neutron economy will suffer.

Development of a Strong Isotropic Phase

Since a large proportion of the damage to uranium under reactor conditions is due to its marked anisotropy combined with a

* Dept. of Metallurgy, College of Technology, Birmingham

relatively low strength, it follows that one major line of attack would be to develop a strong isotropic phase.

An example of such a development is provided by work on a uranium/12 per cent molybdenum alloy which is single phase (γ) over a wide composition and temperature range and relatively strong. Such an alloy has been shown to resist swelling better than α or $\alpha+\beta$ uranium. The phase is isotropic and can be retained to lower temperatures than the γ-phase of pure uranium. Its mechanical properties are far superior to those of α-uranium under the same conditions. The phase diagram of the U-Mo system is shown in Fig. 9. Unfortunately,

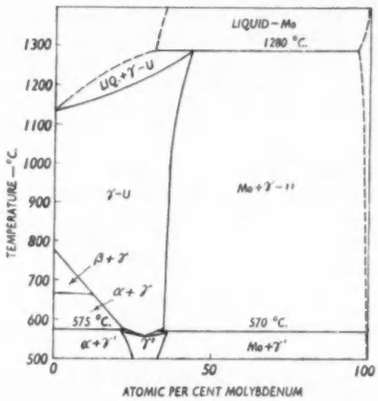


Fig. 9—The uranium/molybdenum equilibrium diagram

molybdenum has a moderately high neutron capture cross section, particularly for thermal neutrons, 2·4 barns. This limits the amount of molybdenum which can safely be introduced. It has been suggested,[13] however, that the γ-phase in U-Mo alloys can be held to a lower temperature under irradiation conditions than under equilibrium conditions when the alloy would normally be $\alpha+\gamma$ uranium/molybdenum. This would allow the use of rather less molybdenum to achieve a satisfactory phase under reactor conditions. Similar suppression of transformations under radiation conditions has been noted in uranium/2 per cent chromium alloys and in uranium/niobium alloys.[14,15] The suppression of the transformation is probably due to the increased difficulty of forming a stable nucleus of the new phase under the disturbing influence of irradiation.

Other alloys with extended γ-phase fields are provided by the systems U-Zr; U-Nb; U-Ti; but the latter introduces a high neutron absorption coefficient.

Development of Porosity to Dispose of Gases

The problem of inert gases arising from fission, transmutation and radioactive decay mechanisms, creating bubbles and swelling in uranium at temperatures rather in excess of 450 deg. Cent., has been mentioned in a previous section. It should be possible to remove the gas atoms from the fuel before they can nucleate and form bubbles if the distance the atoms move to find a free surface is small. The obvious way to provide easy access to a free surface is to make the uranium in the form of a powder compact with a large amount of inter-connecting porosity. It is, in fact, possible to make a compact of this type with uranium powder of about 10μ particle size, but the swelling observed in such compacts under irradiation has not been significantly different from that in solid material and the amount of gas released was very small. Apparently, the gas is able to nucleate bubbles even before it has diffused to the surface of a particle of powder in the compact. There may still be a possibility, at temperatures higher than are normal for fuel elements at present, for the gases to escape before forming bubbles or it may eventually be possible to use even finer powders. For the moment, however, this approach to the problem is not a satisfactory one.[16]

Strong Can Restraint

If, for the present, swelling cannot be eliminated at source, it becomes necessary to use various methods of restraint so that the swelling pressure created by the gas is opposed by strong hydrostatic pressure in an attempt to prevent the density decreasing. The difficulty is one involving a compromise between can strength and neutron economy. In addition, a further heat transfer resistance is created. With a reasonable compromise, this method increases the available percentage burn-up and safeguards against premature breaking away of fuel particles and escape of fission products. The materials which may be considered for canning purposes will be discussed later in this section.

Other Methods of Restraint

Instead of having a complete can as a restraining device, it is feasible to restrain small amounts of fissionable material by dispersing it within a strong non-fissionable matrix. The latter then prevents macroscopic swelling to a large extent and may allow higher amounts of burn-up without failure. The disadvantage of this method is that dilution reduces the active concentration of the fuel for a given volume and also introduces another neutron absorber. The diluent must therefore have a low neutron capture cross section and the volume restrictions on reactor size will enforce the use of an enriched uranium fuel or plutonium. The cost for some time may be prohibitive.

Another type of internal restraint can be provided for uranium matrices by creating within them a rigid network. It is possible to produce, for instance, a network of uranium carbide within uranium; the whole having a density of about 15·5. This system is likely to withstand swelling and thermal cycling across the α/β transformation without suffering the distortions produced in pure uranium.

In general, the amount of alloying element addition permissible without affecting the neutron economy too much is not sufficient to enhance the strength of the fuel element enough to withstand radiation damage. However, if a concentration of alloying element was made in the outer regions of a fuel element and pure uranium or a uranium-rich phase contained within it, it might be possible to get adequate properties from the outer material to support the whole without unduly affecting the neutron economy. A powder metallurgy method could be used to achieve the non-uniform distribution of the alloying element.

The materials and methods which may be used in producing the various types of internally restrained fuel elements are worth studying. As an example of the dispersion of enriched uranium in a pure metal phase, it is possible to design a feasible fuel element of aluminium containing slightly less than 2 atomic per cent of U235 as highly enriched uranium.[17] Aluminium-uranium alloys about this composition, after working and recrystallisation, have a structure in which the dispersed phase, predominantly UAl_4, is in equilibrium with an aluminium phase containing virtually no uranium in solid solution (see Fig. 10). This example is also illustrative of a dispersion system which can be produced by melting and casting. The cast material solidifies with a fine, needle-like precipitate of UAl_4 dispersed in an aluminium matrix. After hot-rolling at 430 deg. Cent., a matted needle structure of the UAl_4 in

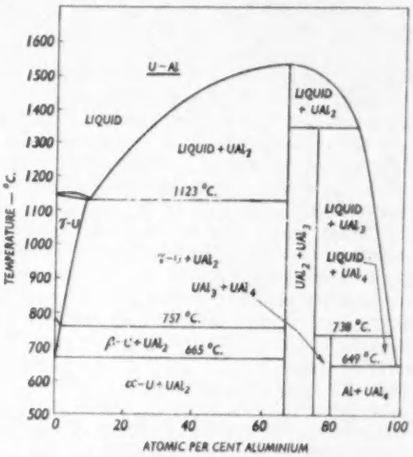


Fig. 10—The uranium/aluminium equilibrium diagram

aluminium is produced, but on annealing for a time about one hour at a temperature between 400 deg. and 600 deg. Cent. the needle structure agglomerates into a satisfactory coarse dispersion. Other dispersion systems which have received attention are UO_2 in Al, UO_2 in stainless steel, uranium in thorium and uranium–zirconium alloys of a precipitation type.

A properly designed fuel element of the dispersion/matrix type calls for a uniform dispersion of the fissile phase in the non-fissile matrix. The particle size, shape and distribution should be such that the region of damage due to irradiation of one particle does not overlap the damage zone of the next. In this way, at all times up to processing of the partly burnt up fuel element, there will be a continuous network of relatively little damaged matrix. The fissile material should be as rich in fissile uranium as possible and sufficiently strong to retain its size and shape during fabrication. Interaction with the matrix should be at a minimum and the matrix must have adequate mechanical properties, even under irradiation, to hold the macroscopic dimensions of the fuel element constant. Both the dispersed phase and the matrix should have low neutron capture cross sections. Additionally, the matrix should have a good thermal conductivity, low coefficient of thermal expansion and metallurgical compatability with any cladding which is to be used.

Obviously, this is a rigorous scheme of properties and to superimpose on it the added difficulties of melting and casting would reduce the number of possible systems to a very low level. Fortunately, many more systems become possible if powder metallurgical methods are introduced. Before considering these methods, it would be advisable to outline the use of ceramic fuel elements, particularly since they too are almost entirely produced by powder methods.

Ceramic Fuel Elements

The resistance of ceramics to radiation damage and their general properties under reactor conditions are encouraging. At the same time they have a lower fissionable material density than the pure fuels and they are prone to brittle failure, particularly under

thermal stress. Provided the pieces can be held closely together in some way, the actual cracking need not introduce any problems of dimensional instability, but it does mean that no reliance can be placed on the fuel from a load bearing point of view.

The types of ceramics likely to be of interest are uranium oxide, or the oxide dispersed in various matrices, such as the metals discussed above, or beryllia, graphite, and thoria, for example; uranium carbide or the carbide dispersed in silicon carbide, for example. In effect, uranium carbide is a self-contained moderator. Both the oxide and the carbide have higher melting points than any of the useful uranium alloys. The oxide has a rather low thermal conductivity and this may mean that, at the required heat extraction rates, the temperature gradient across an element cross section will be very great; even possibly sufficient to result in fusion at the centre of the element. To avoid any dimensional changes, due possibly to thermal cracking, it is likely that such a ceramic element will require strong canning. This will also assist in resisting any fission gases being released from the element. The ceramics do not show anisotropic properties and, in general, are attractive for fuels, but the development of them has been restricted somewhat by the scarcity of suitable basic materials. The carbide systems are inherently less stable than the oxide ones and consequently have received less attention. Even the oxide is not universally stable; in fact, there are four oxides: UO, UO_2, U_3O_8 and UO_3. The most stable is UO_2 and this is the one preferred. Even then, the formula UO_2 is not entirely accurate, since the oxide has a defect structure which will allow the holding of an extra 10 per cent of oxygen interstitially, so the composition varies from UO_2 to $UO_{2\cdot2}$. The disadvantages of its lower conductivity and density have been mentioned and, in practice, the actual density of UO_2 fuel elements may fall below the theoretical because of the impossibility of producing 100 per cent densification with powder methods. Comparative properties of the oxide and pure uranium are:—

	Uranium	Oxide UO_2
Melting point	1130 deg. Cent.	~2800 deg. Cent.
Coefficient of expansion	18×10^{-6} in/in/deg. Cent.	10×10^{-6} in/in/deg. Cent.
Thermal conductivity (c.g.s.)	0·071 (at 70 deg. Cent.)	0·017 (at 100 deg. Cent.)
Density	18·6 grammes per cubic centimetre	10·9 grammes per cubic centimetre

Above temperatures of about 400 deg.–500 deg. Cent., UO_2 oxidises to U_3O_8 and this oxide remains up to the melting point. Some extremely fine UO_2 powders are pyrophoric, reacting exothermally in air to form U_3O_8 in a few seconds.

The oxide can be dispersed in beryllia, but the system as a whole possesses a low conductivity and a marked tendency to cracking. Additionally, it has been noticed that volatilisation of beryllia can take place at high temperatures (1000 deg. Cent.) in the presence of very small amounts of water vapour.[18] For highly rated elements this implies that any coolant gas must be thoroughly dried.

Graphite elements, in which the UO_2 or UC_2 is dispersed by impregnating normally porous graphite or by mixing the fissile material prior to graphitising, have been developed.

Production of Alloys, Ceramics and Cermets by Powder Methods

Before leaving the subject of solid reactor fuels, it is necessary to point out that while melting and casting methods may be economically applicable in a few types of fuel element production, the flexibility of the powder method is invaluable in the more difficult cases. The powder method is very attractive in several ways, particularly when combining a dense metal, like uranium, with a second material which may be very light. Melting and casting would normally lead to segregation which would require considerable efforts to approach homogeneity. Powder metallurgy offers the advantages that materials of widely differing densities can be intimately and uniformly mixed and phases which would react in the liquid state can be kept stable and separate because no melting is necessary. The most difficult aspect of producing satisfactory powder compacts is in choosing the correct particle sizes and shapes for the various components of the system, and all materials used usually have to be very pure. The maintenance of this high purity may require that all operations are carried out in an inert atmosphere, for instance. Finely divided Zr, Ti, U, and UC and UO_2 all come into this category.

As an example of the basic operations, UO_2 powder is fabricated by cold pressing, using a wax binder, in steel dies at 10–50 tons per square inch and sintered at 1400 deg. Cent. or above, or, alternatively, by hot pressing. Hot pressing gives higher densities of compact for a lower press load, but it is very expensive as a process and not applicable to all uranium oxide powders. With some powders carrying carbon as an impurity, formation of carbon monoxide leads to cracking of the compacts. In order to produce maximum density and strength, the compacts must be mechanically worked.

One way in which the working process and the cladding process for a composite fuel element can be combined is the hot co-extrusion technique.[19] In this process the powder compact is placed inside a can of the required canning metal and fitted with a bottom of the same material. The top of the can containing the compact is then sealed by a cone-shaped block of the canning material so that the final result looks like a stubby rocket with the powder compact as the charge. The composite billet is then heated to extrusion temperature, inserted into the preheated chamber of the press with the nose of the billet towards the die, and ejected through the die by direct extrusion. A fitting on the back of the die takes the cone nose of the billet exactly and allows simultaneous extrusion of the powder compact and the can. The cladding is very intimately bonded to the core and the section of material suitable for cutting into fuel elements can be located by a variety of non-destructive testing methods. A similar method has been used for the cladding of normal uranium fuel bars.

Liquid Fuels

It is quite obvious that several of the difficulties associated with solid fuels, particularly growth and swelling, would be overcome by the use of a liquid fuel which has no directional properties and which releases fission product gases readily. Continuous processing of the fuel would be possible and because of the absence of much of the irradiation damage a burn-up of a very high order should be possible. Early adoption of liquid fuels has been delayed by the difficulty of finding a uranium alloy with a sufficiently low melting point and containing sufficient fissile material. It seems that enriched uranium will be necessary to give satisfactory working conditions. If enrichment is considered, then it is possible to use low melting point metals saturated with uranium. Of the various possibilities, bismuth appears to be the best. It has a relatively low neutron capture cross section and it is possible to dissolve enough pure U233 in molten bismuth to maintain the chain reaction. The core of the reactor would consist of graphite with channels through which the U-Bi alloy would be pumped. It has also been suggested that a suitable material for the reactor vessel would be a chromium–molybdenum steel which has good resistance to bismuth corrosion.[20] The liquid alloy would pass to a primary heat exchanger where it would give its heat to an intermediate liquid sodium circuit which would transmit the heat from the reactor. It would not be possible to exchange the reaction heat directly from the bismuth alloy to the steam generator without greatly extending the screening of the reactor. Much development, chiefly on structural materials, will be required before this reactor can become a practical and economic proposition. However, any experience gained should accelerate any required development of liquid plutonium alloy systems. Plutonium having a much lower melting point (640 deg. Cent.) than uranium, may lead to a wider choice of alloys.

Slurries

An alternative to completely liquid fuels is to hold alloyed fissile metals at temperatures in the liquidus–solidus range of the alloy where it will be only partly molten, or to mix insoluble particles in a melt. As an example of the latter, USn_3 in liquid Pb-Bi-Sn is a possibility. These slurries can hold larger quantities of fissile material at practicable temperatures than can true melts. One large difficulty of these systems is that with temperature gradients there will be continual changes in the solid particles in number, size, shape and distribution. This will lead to migration of solids to low temperature areas with consequent lack of power output control and blocking of circuits. With liquid fuels and slurries there is the additional difficulty of liquid metal corrosion of reactor components in the stream.

Fuel Element Canning Materials

None of the fuel elements seriously considered so far in nuclear engineering can be relied upon to fulfil all of the working requirements economically without resorting to some form of container to carry part of the structural load, prevent corrosion, restrain the element from altering its dimensions and prevent loss of fissionable or fission product particles.

The properties required in a canning material are:—

(1) It must be a metal or alloy of low neutron capture cross section which can be fabricated and welded.

(2) It should have a reasonable high temperature strength.

(3) It should be compatible and stable with respect to the fuel and the coolant.

These requirements have led to the investigation and use of both conventional and unconventional metals.

(*a*) *Aluminium.*—Aluminium was the first metal to be used for sheathing of uranium because, of the metals of low neutron capture cross section, it was the most readily available commercially and its fabrication and welding technology were widely appreciated. Very pure aluminium is attacked by water at temperatures of 150 deg. Cent. and over, and also, above this temperature, the creep properties of aluminium begin to decline rapidly. Alloying can help to raise the working temperature to

over 300 deg. Cent. by additions such as 0·3–1 per cent iron and 0·5–2·5 per cent nickel. In coolants, other than water, aluminium responds variously; it is safe up to its melting point in air, carbon dioxide and hydrogen, is inert to helium, but is attacked by sodium, bismuth and mercury.

If not prevented, aluminium reacts with uranium under reactor conditions. Above 175 deg. Cent. the compound UAl_3 is formed and this leads to "pimpling" of the surface of the canned element due to the increased volume of the compound compared with the reactants. This situation can be prevented by creating a barrier layer of suitable material between the fuel and the can which will remain stable with respect to both. Examples of workable solutions to pimpling are the use of an aluminium–silicon brazed bond which does not spread significantly with time in the neighbourhood of 300 deg. Cent., and the provision of an anodic coating on the inside of the aluminium tubing.

Aluminium, in common with several possible canning materials, has a coefficient of thermal expansion greater than that of uranium. (Al. 25in/in/deg. Cent. $\times 10^{-6}$ and U. 16–18in/in/deg. Cent. $\times 10^{-6}$.) This situation can give rise to a thermal ratcheting process unless special precautions are taken. If an aluminium (or magnesium) canned bar of uranium is heated the can expands more than the uranium. In a reactor operating with pressure on the elements, the can would tend to collapse on to the bar. During subsequent cooling the can would try to contract more than the bar and, being in contact with it, the can material would tend to deform plastically. Continued thermal cycling produces permanent distortion and possibly failure of the can. This defect can be prevented by one of two methods. In the first, the uranium can be a loose fit in a very strong can which will not collapse and which would allow independent expansion and contraction of the fuel and the can. This method introduces difficulties in heat transfer and increases neutron absorption. The second method relies on holding the fuel and the can so closely together that they behave as a single unit. The bonding between the can and the fuel has been created by various methods, including high temperature duplex rolling and extrusion, by powder metallurgy techniques and by casting the fuel into cans acting as moulds. In each case, continuity between the fuel and the can may be achieved, but it is necessary for the bond to be stable and for diffusion or reaction between the materials to be slow under reactor conditions.

Taken all round, the properties of aluminium as a sheathing material are not completely satisfactory and not apparently capable of development for higher temperature applications than are in use at present. In alloyed form, it is still a possible material for use with high pressure water reactors operating at surface temperatures up to 300 deg. Cent.

(*b*) *Magnesium.*—Magnesium has room temperature properties of the same order as those of aluminium, but it is capable of standing stresses to a slightly higher temperature than aluminium under the same circumstances. Even so, it is alloyed to improve its mechanical and corrosion resistant properties for canning purposes. In this way the temperature of appreciable reaction with air is increased from 300 deg. Cent. to the melting point. The pure metal is reactive with water above 70 deg. Cent., with CO_2 above 550 deg. Cent., and with hydrogen above 450 deg. Cent. Helium has no action on magnesium, but sodium, bismuth and mercury all attack it. Neither the pure metal nor its usable alloys react with uranium. As mentioned under aluminium, magnesium has a coefficient of thermal expansion (26×10^{-6} in/in/deg. Cent.) greater than that of uranium. The neutron absorption cross section of magnesium (0·059 barn) is lower than that of aluminium (0·22 barn) and is quite acceptable. It must be remembered, when dealing with the absorption cross sections of the canning materials, that the addition of small quantities of alloying elements can profoundly affect the overall absorption cross section. For instance, structural aluminium alloys contain small quantities of manganese (neutron absorption cross section 12·6 barns) and these can double the overall absorption cross section of aluminium.

The desire to increase high temperature strength, decrease high temperature reactivity with the coolant circuit and develop good weldability without cracking, led to the use of dilute alloying techniques. From this work came the oxidation resistant magnesium alloys known as "Magnox," based on magnesium with up to 0·1 wt. per cent Be and up to 0·2 wt. per cent Ca.

A mechanical method for locking "Magnox" cans on to uranium bars has been developed and can be extended to other canning materials. The uranium bars are provided with a series of circumferential grooves and after canning, the composite element is heated under hydrostatic pressure so that the Magnox flows into the grooves.

The development of reactors to still higher temperatures, requires alloys improving on "Magnox." Magnesium has the unattractive features of a low melting point and a high volatility even below the melting point. Of the higher melting point materials, zirconium and beryllium have a low absorption cross section for thermal neutrons.

(*c*) *Zirconium.*—Zirconium has a relatively high melting point (1850 deg. Cent.) and thermal stability. Its mechanical properties are not very encouraging in certain respects, particularly creep strength at moderately high temperatures. It reacts slowly with uranium above 800 deg. Cent. and rapidly in the molten state. The thermal expansion coefficient of zirconium (6×10^{-6} in/in/deg. Cent.) is considerably lower than that of uranium. Two impurities associated with zirconium have deleterious effects. Any hafnium contamination must be eliminated because of the very high neutron capture cross section of that element. The addition of tin, iron and nickel as dilute alloying elements to zirconium, renders it resistant to water at temperatures of 300 deg. Cent. and neutralises the deleterious effect of nitrogen, which occurs as an impurity in zirconium produced by the Kroll process. The reactivity of zirconium with other possible coolants varies. With wet CO_2, reaction starts at 450 deg. Cent., but at a higher temperature if the gas is thoroughly dry. The reaction with hydrogen starts as low as 150 deg. Cent., but again there is no action with helium. Of the liquid coolants, bismuth attacks above 600 deg. Cent. and mercury is also reactive, but the reaction between zirconium and liquid sodium depends on the oxygen content of the sodium. When the oxygen content is less than 2 p.p.m. the sodium is harmless, but when the oxygen content is 20 p.p.m. the sodium embrittles zirconium, above about 250 deg. Cent. The neutron absorption coefficient of zirconium (0·18 barn) is satisfactory.

(*d*) *Niobium and Tantalum.*—Both niobium and tantalum are capable of use as canning materials superior to zirconium. They both have rather higher neutron capture cross sections than zirconium, but both are acceptable. They have higher creep strengths and thermal conductivities than zirconium and are more tolerant of oxygen in liquid sodium though the reaction does occur. The ductility of niobium particularly is very dependent on its oxygen content and the extraction and processing of niobium has undergone considerable investigation and development. Nevertheless, these two metals have not yet reached the stage when they can be made economically available in large quantities.

(*e*) *Beryllium.*—Beryllium, which has a high melting point, 1350 deg. Cent., a low neutron capture cross section, 0·009 barn, and considerable strength at elevated temperatures, is an ideal sheathing material from a reactor point of view. It is, however, a very difficult metal to handle because of its extreme toxicity and its brittleness at room temperatures. It has been suggested that if beryllium could be obtained sufficiently pure it would be ductile at room temperature. Fabrication methods for sheet have been evolved which give ductility in the plane of the sheet but not in a direction perpendicular to the plane. Alloying has not been successful in improving the ductility of beryllium because of the ready formation of stable brittle compounds. The ductility of beryllium increases markedly above 200 deg. Cent. and, since it will be above this temperature in the reactor, it is likely to be satisfactory as a canning material once it is fabricated. The major difficulties lie in its production on a large scale and its economical fabrication. Work on conventional canning methods using beryllium is hampered by its low transverse ductility and, in addition, by the difficulty of obtaining ductile welds. Welding or brazing is possible, though complicated by the rapid oxidation of the metal in a normal atmosphere. Alternative methods of sheathing uranium, such as co-extrusion of uranium and beryllium in a similar way to that described for sheathing powder compacts, have been tried and may provide a solution to the brittleness problem.

The corrosion properties of beryllium are again varied, but in some respects promising. It does not react significantly with air below 800 deg. Cent., CO_2 below 550 deg. Cent., hydrogen below 600 deg. Cent., and not at all with helium, but it is attacked by bismuth, mercury and water. Processes of electroplating with atmospherically more stable metals, such as copper, nickel, iron or silver, may give further protection.

(*f*) *Canning Materials for Fast Reactors.*—Many more structural and cladding materials become available when a higher neutron capture cross section can be tolerated, as in a power reactor using enriched fissile elements. Even so, good neutron economy is still required and, in general, this requirement is supplemented by that of reasonably good high temperature strength. Thus, materials such as stainless steel become possible choices together with a further range of metals and alloys based on niobium, tantalum, molybdenum, vanadium, in addition to nickel and chromium.

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(*To be continued*)

Vauxhall Works Extensions

During the past four years about £36,000,000 has been spent by Vauxhall Motors, Ltd, on plant expansion and modernisation to increase the firm's productive capacity from 130,000 to 250,000 cars, vans and trucks a year, at its Luton and Dunstable factories. Most of this money has been spent in connection with the Luton factory where there is now a production area of just under 5,110,000 square feet, of which some 1,500,000 square feet is in a new body building and car assembly block. Other work carried out under the programme includes the extension of the Dunstable works from 120,000 to 1,250,000 square feet, the re-equipment of the Luton machine shops and the erection of a new parts and accessories building of 500,000 square feet at Dunstable. Part of the body assembly line at Luton can be seen on the left.

A MAJOR scheme of modernisation and plant extensions just completed at the Luton works of Vauxhall Motors, Ltd., has involved the re-equipment of the machine shops and the construction of a new factory block of some 1,250,000 square feet for housing a press shop, the body building, painting and trimming sections, and the final car assembly lines. The finished mechanical components from the machine and other shops are fed into the new assembly block by conveyors, and before dealing with the new block and its equipment we propose to describe briefly some of the new equipment of machine production lines in these shops.

The manufacture of engine, gear and axle components and their assembly is carried out in a building some 1760ft long and 480ft wide adjoining the new factory block. From the three main assembly lines for engines, front axles and rear axles, an overhead monorail conveyor transports the units in sets of three to the assembly block. Some particularly interesting transfer machines of advanced design have been developed for the production of the components and the section used for the machining of cylinder blocks and heads is very impressive.

In the cylinder block line four main transfer machines in use include three of Ingersoll construction with thirteen, six and nineteen stations respectively, and two Barnes machines of fifteen and thirty-three stations linked together. These two Barnes machines can be seen in Fig. 1. These transfer machines are linked up with miscellaneous machines, washing, testing and inspection equipment giving a total of more than 100 machining stations. The more than 1400 operations performed in this section are carried out under the control of thirty-two men. The massive control cabinets for some of these transfer machines are mounted on gantries and special duplicate circuits are incorporated to enable maintenance staff to track down electrical faults rapidly. Inspection stations and probes, or feelers, are built into the machines for the detection of broken or worn tools, which can quickly be replaced from adjoining tool exchange cabinets. The line is designed for the production of both four and six-cylinder blocks, and it is stated that the change-over from one to the other can be made in about two hours. A line for cylinder-head production contains fourteen-station and sixteen-station transfer machines, nine fine borers and a special Asquith press for valve guide assembly purposes. Other highly mechanised lines are concerned with crankshaft, piston, connecting-rod, valve and other component production.

Fig. 1—Pair of transfer machines linked to make 48 machining stations in the cylinder block line

A section of the 345ft long slat-type bench conveyor used for engine assembly is shown in Fig. 2. This conveyor passes down the centre of the shop and the components are delivered to it in the appropriate sequence. An unusual " motoring " section of this line consists of a system of electric motors and pumps, twenty in all, which attach themselves automatically to the new engines, driving them around at 470 r.p.m. Whilst the engines are rotating warm, clean oil supplied by the pumps flushes the engine out at a rate of 2½ gallons per minute. Each engine and its electric motor travel along together for twenty-seven to thirty minutes, whilst inspection and minor adjustments are carried out. Gearboxes are assembled on a similar slat bench conveyor about 100ft long and this conveyor is served by a monorail system which delivers sets of parts to the required station. From this line the gearbox units are delivered by overhead monorail to the engine assembly line.

Rear axles are assembled on a bench level double-strand chain conveyor to which the axle housing, sleeve and flange assemblies are delivered by an overhead monorail conveyor, which also circuits the machining area. The rear axle line delivers completely assembled units to the main transporter conveyor which feeds the final assembly line in the main car production building. Front axles are assembled on a conveyor of similar design and delivered to the main transporter system.

New Factory Block

The new factory block is L-shaped: the foot of the letter, covering an area 882ft long by 400ft wide, accommodates the press shop and running the full length of the foot is a 100ft wide steel stores separated by a wide gangway from the press section.

Fig. 2—Engines being assembled on a conveyor at the end of which an automatic preliminary running-in process is carried out without interrupting the flow of work

This stores has a completely unobstructed floor and is served by three 25-ton overhead cranes over its full length. The four entrances for road vehicles are of tunnel design with inner and outer doors operated through photo-electric equipment, so that only one door is open at a time. This eliminates heat loss from the interior of the building.

One of the eleven main bays of the press shop is reserved for future requirements and an impression of one of the heavy press bays is given in Fig. 3. Below nine of the ten bays is a continuous basement in which there is situated the steel girder support structures for the Clearing underdrive presses. A series of conveyors in the basement area receives the sheet metal off-cuts from the presses and transfers it to a central baling plant. The equipment of the press shop includes some 222 presses arranged in twenty-six lines, each line being concerned with one component body member. Set in some of the press lines are multi-spot welding machines to which the pressings are fed in correct sequence for the building up of sub-assemblies for feeding in by a conveyor system to the main assembly section. The 118 underdrive presses in this shop range in capacity up to 1500 tons and the heaviest weigh some 200 tons.

All but two of the presses are new and many of them are fitted with loading and ejecting devices and other labour and time-saving mechanisms, complete with built-in controls. All heavy and medium machines are equipped with developments of the "Iron Hand" device for unloading, and the lines of machines are also connected with portable band conveyors. The many new loading devices in use are mainly of compressed air and piston design, synchronised with the stroke of the press and operated by remote control. Some of the unloading devices are used in conjunction with turn over mechanisms leading to the transfer conveyor equipment. Shuttle loaders are also used in connection with multi-spot welding machines and the double-acting presses on the line set aside for the production of door assemblies, which are made in eight types, and luggage boot lid assembles made in two types. Three Schuler transfer presses are used for the production of small components, such as fan pulleys, generator pulleys, and some deep-drawn pressings. These machines are coil-fed and can produce some 900 components per hour.

A very large proportion of the sheet metal used in the shop is supplied to the works in the form of coils up to 6ft wide. In a preparation section at the head of the press lines, the coil is blanked directly on equipment which includes a cone carrier, a set of McKay rolls, a deep pit (20ft) for taking up slack, a timer roll and a single-acting clearing, blanking and shearing press. All these machines are linked under automatic control, and equipment for the automatic stacking of blanks is installed for some of the operations.

A scrap baling system, situated in the basement beneath the press shop, comprises a network of eight apron-slat conveyors. Off-cuts are delivered by chutes on to the subsidiary conveyors delivering to a main conveyor, which deposits the off-cuts on to a short run conveyor which leads into the baler. The conveyors are controlled by the baling machine operator, and a warning system, broadcast throughout the basement, indicates when conveyors are to be started up.

The bales, which weigh approximately 4 cwt to 5 cwt, are compressed to a standard width, although their length and height can vary. They are delivered through a tunnel by a pusher bar and twin-chain type conveyor to the loading dock outside, where an electro-magnetic hoist lifts the bales on to the waiting road vehicles.

In the main press shop three overhead monorail conveyors deal with the movement of door and luggage boot lid panels; one carries outer panels from the presses to the sound-deadener spray plant and back to the welding machines, and the second circulates from the presses to the welding machines and back. The third conveyor, which carries welded assemblies from the press shop to the neighbouring body-building shop, descends *en route* into a storage basement which has a floor area of 30,000 square feet.

A panel stores forming part of the press shop has an area of 106,000 square feet, and is divided into three sections for large panels, small components and an export pressings collection and collation area. The large panel storage area accommodates such items as roof panels, wings, bonnets and floor panels, which are packed into special pallets designed for each panel. Smaller components are packed into stackable stillages. The export pick-up and collection area is partly loading dock and partly stores. Boxes, specially designed to accommodate panels, sheet metal components and sheet metal assemblies, respectively, are transported from the export boxing department to this area for loading.

Body Building Shop

The body shop at Luton covers an area of 223,100 square feet, and with ancillary areas there is a total of 353,400 square feet of floor space utilised for the manufacture of sheet steel bodies. This shop is supplied with components and sub-assemblies by a system of six overhead conveyors, with a total length of approximately 5500ft. Two principal conveyor systems, operating at floor level, are used for the body building operations, one being used for body welding, the other for body finishing. The body welding conveyor is an endless chain 828ft long, arranged in the form of a long rectangle with sharply radiused corners. It is served by and synchronised with the two overhead conveyors

Fig. 3—One of the eleven bays in the new press shop with part of the extensive underdrive press installation

that carry the right and left-hand side frame assemblies.

The body finishing conveyor runs near the body welding conveyor; on it the doors, trunk lids and other body fittings are added, and all sheet metal finishing, polishing and surface rectification prior to painting is carried out.

A section of the body shop is allocated to door assembly finishing, and to it doors in a partly completed condition are delivered from the press shop by overhead conveyors having a total length of approximately 2450ft. Doors are assembled on two roundabout systems, each 12ft in diameter, and having eight welding fixtures. These systems rotate in synchronism with a short door welding conveyor system situated alongside at ground level, and on which a series of smaller finishing operations—brazing, welding and polishing—are carried out. This conveyor consists of forty-two trucks drawn by a continuous chain on a rectangular path.

The key operations in the body shop are centred on the body welding conveyor on which forty-two specially designed jig trucks travel in continuous procession through the welding stations located in sequence throughout the system. Each jig truck consists of a platform about 13ft long by 5ft wide, mounted on two fixed castors at the front and a swivel castor arrangement at the rear. On this platform are a pair of precision locating units for the front and rear underbody assemblies. The permitted tolerance on the locating points and the fitting of component back-ups in manufacture was 0·002in, and the platform itself has an overall tolerance of 0·010in. On each side of the jig trucks are two butterfly clamps which hold and locate the side frame assemblies in relation to the underbody.

Thirty pairs of side frame fixtures are provided for the main body welding conveyor, each pair being carried to the proper station at the right time by a synchronised overhead conveyor system and moving along with it until welding of the body structure is complete. The transfer and locking of loaded side frame jigs to the body jig truck is carried out manually from a pair of switch rails in the overhead conveyors. The side frame fixtures, when unlocked from the body jig truck on their return journey, pass through subsidiary welding stations, where a complete body side frame assembly is produced ready for loading into a body jig truck on the main conveyor. The main structure of the side frame jigs is of a special preformed section which gives the required high standards of strength and rigidity and resistance to deflection. Each of these side frame fixtures carries all the locating and clamping devices needed to ensure consistently accurate sub-assemblies.

The body side frame assembly consists of the rear quarter assembly; centre pillar assembly; rocker panel assembly (door sills); the front body hinge pillar assembly, and the roof side rails. The fixtures used in their assembly establish many important dimensions of the body shell, and control the co-ordination of all door apertures. The jig frame has a pair of locating posts which fit into the butterfly clamps on the body welding jig truck.

On the body shell assembly circuit, the load/unload station is situated right beside the area where the first units to be loaded on to the jig trucks are produced. This area produces, on press-welder equipment, the front and rear underbody assemblies, which together form the floor (and also chassis) of the car. These two units are bolted rigidly down on to their locations at ten points; four at the front—to correspond with the alignment of the front suspension system previously established; two close to the centre body pillars; two at the mounting positions of the front anchorages of the rear springs; and two at the extreme rear of the underbody assembly. A set of smaller sub-assemblies then laid loosely on the truck, ready for subsequent welding into their correct positions, include the dash, scuttle and pedal panel assembly, and the rear shelf and seat-back assembly. The truck now enters the side-frame loading station.

When a body jig truck enters the loading station a pair of side frame jigs, each complete with a welded body side frame assembly (left and right-hand), is ready waiting to be locked into position.

The side frames and jig truck are also rigidly locked by quickly attachable sets of lateral spacer bars. The whole unit then travels through the welding stations, during which the body shell is welded into one integral unit. Following a series of smaller operations, the body shell is then unbolted from the mountings and placed on the finishing line alongside.

The body finishing conveyor is a pegged floor-chain which pulls a large number of lightweight trucks along through the finishing stations. The first series of operations are concerned with the dressing and preparation of welded joints. When this has been completed the body shells pass into the sanding booths and, after sanding, the shell is fitted with doors and trunk lid, and the subsequent operations are all devoted to treatment of the surface of the body prior to painting and hinge adjustments. Inspections of surface finish and rectification of skin panel surfaces are the final operations undertaken before the shell is transferred on to the phosphate section overhead storage conveyor, which employs special slings for carrying the complete body shell.

An overhead mono-rail conveyor delivers the body shell to the paint shop on the floor above. This conveyor carries the body shell into the body phosphating and rust-proofing system, and has an effective length of 2183ft. After rust-proofing and underbody dip, the body phosphate conveyor transports the shells into a pent-house above the paint shop. This pent-house holds all the drying ovens, furnaces, air replacement plant and pumping gear associated with painting operations. On descending from the pent-house the body shells are ready for another underbody dip and various sealing operations. Prior to sealing they are transferred by a quick release system to a body primer and mono-tone conveyor system. This conveyor after passing through the primer spray booths and up into the pent-house for drying and stoving, returns to the wet sanding deck. After wet sanding the body is once more dried in the pent-house and enters the colour spray booths, again passing to the pent-house for drying and cooling.

The bodies, now in full colour, are ready for polishing and for this operation they are placed on a floor chain and peg conveyor which carries a number of light wheeled trucks. After polishing the bodies pass directly out into the trim shop.

A separate part of the paint shop is devoted to the painting of large sheet metal parts, particularly wings, bonnets and radiator lower grille valances. This painting system again comprises three conveyors linked and in synchronisation. The sheet-metal components are delivered from the panel stores by conveyor to the paint shop, where they are off-loaded by hand and transferred to the sheet metal phosphating conveyor. This conveyor carries the sheet metal parts through phosphating only, from whence they are transferred to a second conveyor which carries the parts through a primer dipping operation. After primer dip the parts are transferred to a third conveyor for transport through the colour spray booths. On descending from the colour drying oven in the pent-house, the components are transferred to a floor conveyor, which carries polishing heads, and from this section they are delivered to assembly stations in the trim shop. The small interior sheet metal components fitted to the body of the car are rust-proofed and painted on a separate system in the paint shop.

Body Trimming Shop

The body trimming shop on the first floor of the new building is equipped with a conveyor which is 3060ft in length, and carries 167 body shells on a pegged floor chain which pulls the lightweight trucks, on which the bodies are mounted, through the sequence of trim operations. The trim shop occupies an area of 218,700 square feet and

Fig. 4—The body trim conveyor which holds 167 bodies in process of trimming

the trim stores, on the same floor, has a floor area of 60,750 square feet. A further 26,325 square feet in the basement is set aside for seat spring-case manufacture, and brings the total area in which trim activities are undertaken to 305,775 square feet.

In addition to the main trim conveyor, part of which is illustrated in Fig. 4, the shop contains several areas which produce the components fitted to the body shell. These include front and rear seat assembly, steering column and steering wheel assembly, bonnet assembly, upholstery and carpet cutting and sewing, door trim pad assembly, windscreen and rear window assembly, ventilator assembly and rear quarter and arm-rest assembly. These sections are located as near as possible to the appropriate assembly station and the sub-assembly operations are carried out on benches and special tables.

The body trim assembly line is fed direct from the paint shop with painted body shells, which are pushed into an automatic marshalling section which consists of four conveyors laid side by side, each 68ft long. Each holds eight bodies mounted on their respective trucks. Switches in the conveyor shunt the bodies from the rear of the conveyor up to the front as they are removed from the marshalling banks and pushed on to the main trim conveyor. One section of this conveyor passes through a tunnel 100ft long in which batteries of high pressure water jets are used to test the waterproofing of the body shell. A second water spray tunnel ensures that rectification measures are effective. When the body is completely trimmed, it arrives at the starting point alongside the marshalling bay where, through an aperture in the floor, it is lowered by means of an air-hoist and special grab down to the body mounting station on the final assembly line which runs beneath.

Assembly Line

The final assembly hall is approximately 1000ft long by 180ft wide, and an assembly conveyor 960ft long, which traverses almost the full length of the hall, is in two synchronised and linked lengths. The first length is a single strand slat conveyor which begins at bench level, slowly rising to shoulder height. Over this length the front axle, rear axle and engine units are mounted on the body shell, lowered from the trim shop on the floor above. Wheels and tyres assembled in the basement are brought by an overhead roller conveyor to the assembly station on the main assembly line. An automatic system is used to deliver the wheel assemblies on either side of the conveyor alternately.

Once the car has wheels fitted, it is transferred automatically from the single strand conveyor to a two-strand slat conveyor, on which final assembly is completed.

At the end of this assembly line provision has been made for the extraction of exhaust fumes emitted when the engines are started up for inspection. This system consists of a long extraction duct suspended from the ceiling immediately above the assembly line, and as each car enters this section of the assembly line it is coupled to the duct by a flexible pipe which is inserted in the exhaust pipe. Pipe and car travel along together until the car is driven off the end of the line. After inspection, each car is driven to a head-lamp focusing and toe-in adjusting station. Before reaching the station the car passes over a grid which brings the shock absorbers into " life " so the car, when in the head-lamp focusing station, will assume a natural posture which coincides with its normal position when travelling along the road.

In the subsequent roller test inspection section there are four sets of free-running rollers which support the rear (driving) wheels so that an inspector can put a car into any gear and carry out what is virtually a simulated road test. It is stated that, with experience, a skilled inspector can pinpoint any mechanical fault over the equivalent of 1 mile run off on the speedometer. Cars are then driven on to one of three parallel floor-level slat conveyors, where they run over well-illuminated pits which permit work to be carried out beneath. For the final length of these conveyors, cars run through high intensity light tunnels, where finish imperfections can readily be detected.

The final finish section consists of two parallel floor-level slat conveyors, in the first part of which are spot spray booths for paint rectification work and drying-off ovens and a body polishing section.

Plating Shop

An important part of the expansion scheme has been in the re-equipment and replanning of the plating and radiator building facilities, which are now housed in a shop with a floor area of some 251,500 square feet and of which 65,700 square feet have been set aside for plating work. The automatic copper, nickel-chrome and zinc plating plants of advanced design include two Deinert automatic copper plating plants, a Canning automatic nickel-chrome plating plant, a new Canning automatic nickel-chrome plating plant, a new Canning automatic copper plating plant, three automatic zinc plating plants, barrel plating and heat treatment plating plants, and manual plants for copper, nickel and chrome plating operation.

Each Deinert plant is completely automatic in operation and consists of a series of twenty-two process tanks placed in a narrow oval circuit around a central conveyor system. Pairs of vertical guide rails act as spacers as well as tracks for raising and lowering loads of components. Wheeled trolleys carrying component-loaded flight bars which extend out over the process tanks, run up and down the vertical guide rails, according to the process cycle. The trolleys are lifted and lowered by a hydraulic bridge operated by three mechanically linked rams. The transfer of component-loaded frames from one process tank to the next one is accomplished by a combination of lifting by the hydraulic bridges, horizontal movement by the central chain conveyor system, and lowering by the bridges. The capacity of each of these plants is 8 square feet of plating per suspender jig load, and forty-eight jig loads are delivered per hour, giving a total output capacity of 384 square feet of plating per hour.

The installation for the copper, bright nickel and chrome plating supplied by W. Canning and Co., Ltd., is in two sections. The first section applies a heavy copper deposit which is polished prior to being conveyed back to the bright nickel and chrome section of the installation from which components are passed directly to the assembly lines. Each unit is designed to handle 100 jigs per hour, each jig being loaded with approximately 8 square feet area of components. The 200 jigs per hour total throughput is thus equivalent to 1600 square feet of plated work.

In the heavy copper plating plant two rows of twenty-two process tanks lie parallel to each other 9ft apart. Around the plant is a massive steelwork structure which supports the conveyor system, rectifiers, transformers and storage tanks and the platform and catwalks for the plant operators. A conveyor system runs between the tank rows supporting a series of flight bars which extend over the tops of the tanks on either side. There are 138 flight bars spaced on a twin strand link conveyor and held in position by flared " U " shaped plates attached to links in the conveyor. During plating the bars are carried by the conveyor on hard drawn high conductivity copper track above the tops of the process tanks. At the discharge end, the conveyor carries the flight bars upwards and back over the length of the plant to the loading end.

The conveyor system is operated by a system of twenty-three elevator towers between the rows of tanks. These towers are fitted with a carriage and when a flight bar approaches a transfer station a limit switch starts the elevator motor. The carriage then moves up the tower, lifting the flight bar with it, and at the end of the travel a limit switch stops its movement. The flight bar is then slid forwards by a separate system and the distance moved is sufficient to clear the lips of the abutting tanks and allow the jigs to be lowered cleanly into the next process tank. When the flight bar reaches this position, the lift motor reverses and the elevator is lowered, placing the bar back on the moving conveyor, the speed of which is 12½in per minute.

Serving the main conveyors are auxiliary

Fig. 5—Cars pass in through the car conditioning and final finish and inspection areas

conveyors which, in addition to feeding the process conveyor with loaded jigs and receiving the plated work, present and accept the jigs at the automatic loading and unloading machines. Finished work from the polishing section is passed to five loading bays, each of which handles a particular group of articles. The feeding conveyor has a series of trolleys which are brought on loops into the loading bays, where they are loaded with jigs filled with the polished work and moved on to the conveyor which transports them to a storage point before the loading unit. At the correct time four jigs are carried by the trolleys to the loading position, where they are stopped for four pairs of arms from the loading unit to lift and place them on the flight bars of the plating plant conveyor.

The empty trolleys then by-pass the plating plant and are brought to the discharge end of the process line. Meanwhile, four jigs of processed work at the discharge end of the plating line are lifted by the unloading unit, rotated through 180 deg. and placed on to the trolleys of the conveyor. At a signal, the trolleys are moved along the conveyor to the unloading section, where each trolley selects its appropriate bay.

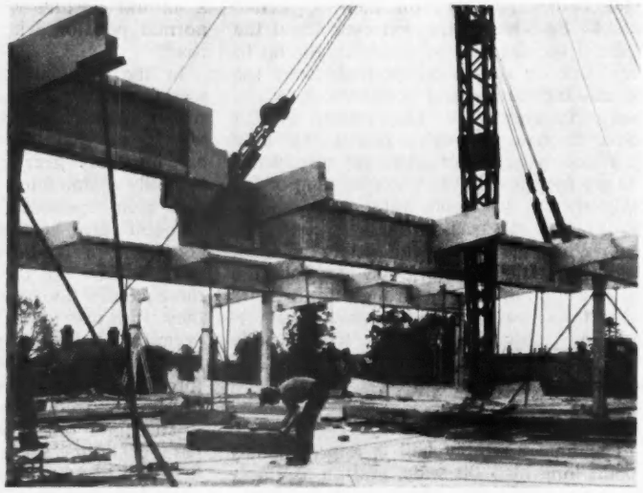
The design of the nickel and chrome plant is generally the same as the heavy copper installation, but it is slightly larger and the plating tanks are in two parallel rows 9ft apart with thirty-two tanks in each line.

Much of the polishing of metal components has been mechanised. Components are clamped on to fixtures, by which they are carried on a conveyor system to a series of polishing mops mounted on universal heads. The heads can be placed in a number of positions to run statically or they can be mounted on a counter-balanced device which permits the head to move in and out, or up and down, depending on the shape of the surface to be polished. Polishing mops are in some cases shaped to conform with the contours of components. Each polishing mop is provided with mechanical or electro-mechanical applicators which automatically cover the mop with the required amount of compound.

Rotary machines of two kinds are used. On one, fixtures are mounted on self-aligning and self-indexing tables, with polishing mops positioned at each station around the perimeter of the table. On the other, the conveyor system has repositioning or jig-rotating devices at selected stations so that the various surfaces of awkwardly shaped components can be presented to the mops in turn.

Two-Storey Prestressed Concrete Structure

Precasting of beams in sections, and site assembly and erection are exemplified in a prestressed concrete building at Southampton. The suspended section of the centre span of a main roof beam is shown being lifted into position in the heading illustration. It has been assembled with three diaphragms which also form cantilevers for the support of the suspended sections of the secondary beams.



THE accompanying drawing shows details of the structure of a two-storey building completed recently at Southampton, and which serves as a factory, garage and showroom. The main beams have been built from conveniently short precast elements of 2 tons or less in weight, manufactured away from the site, and then assembled and lifted into position. Restricted space and access at the site, and an early completion date were the factors which favoured such a method of design and construction.

The building is a two-storey structure, 200ft long and 158ft 6in wide. Except in the front bay (the showroom) columns form three spans across the width of the building of 47ft, 62ft 8in and 47ft. The external columns have a section of 24in by 12in and the two inner rows are 20in square. All columns are at 19ft 10½in centres.

The prestressed I-section main beams are 3ft 10½in deep overall and were precast in elements 7ft 9in long, each having a diaphragm at one end. Caulked mortar joints were made between the elements. The centre span consists of a 52ft 8in beam suspended between 5ft cantilevers from the side spans, a system found to be much more economical than one with three continuous spans. At the points of suspension there are 3in diameter mild steel rollers between the halved ends of the beams, and the prestressing cables are arranged to resist the bending and shear stresses in the halving. Side spans were stressed with 8- and 12-wire Gifford-Udall-CCL cables, made of 0·276in diameter wires, in "Ductube"-formed ducts. In the suspended spans, cables of the same diameter were used, with special 36-wire steel anchor plates to simplify the design of the halved ends of the beams.

The beams were assembled and jointed on the ground floor slab and lifted into position with two erection masts. Four cables in the cantilevered beams and five cables in the suspended beams were stressed before lifting. The remaining cables were tensioned after the secondary beams and floor panels had been placed. In the cantilevered beams, these cables were stressed from outside the building.

The I-section secondary beams, which are supported on brackets formed on the diaphragms of the main beams, have a total depth of 2ft 1in and are at 7ft 10in centres. They were pretensioned with 0·2in diameter crimped wire, and erected by a light mobile crane.

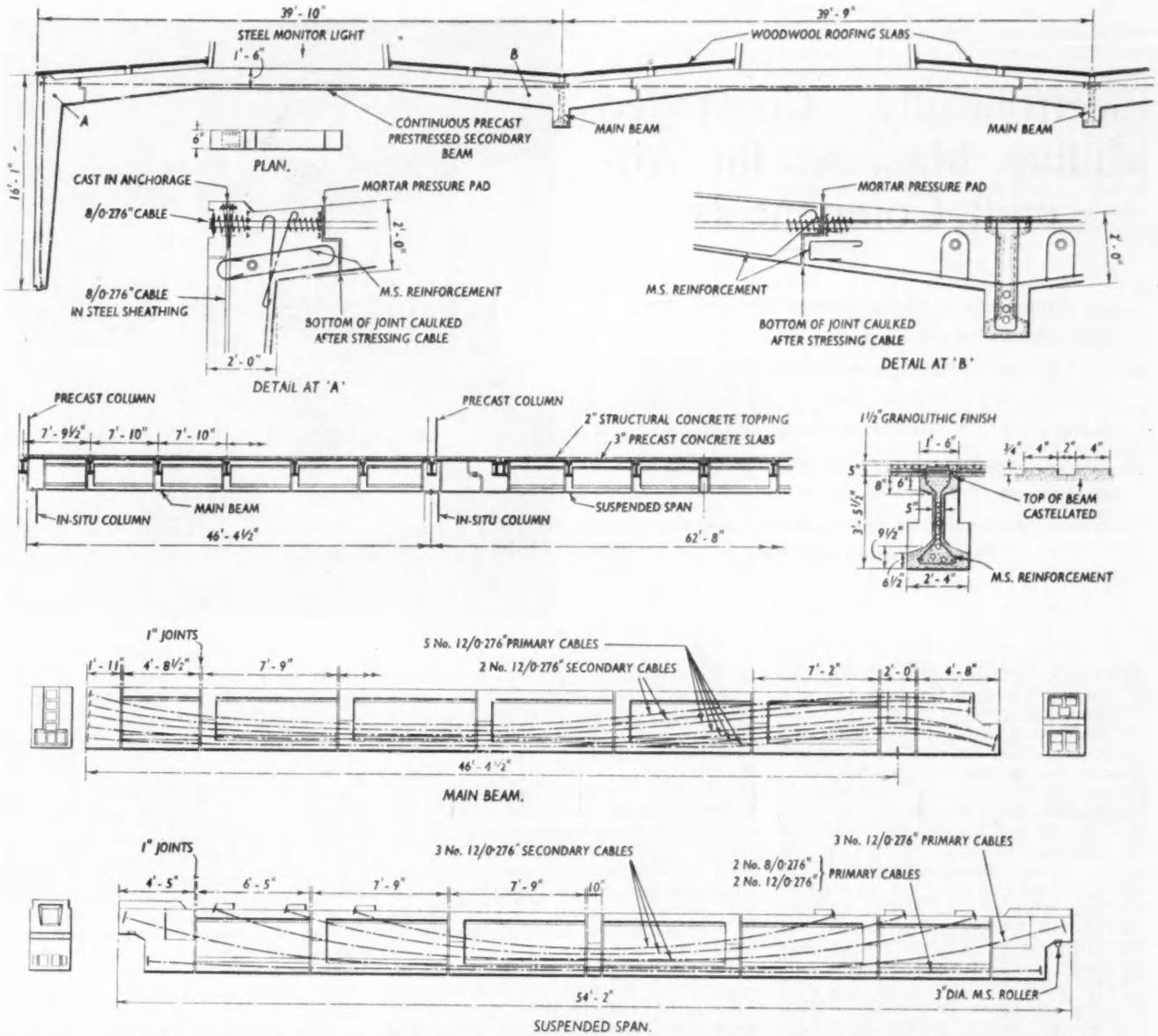
To provide bond with the *in situ* topping of the floor slab the tops of the main beams are castellated and the secondary beams are transversely ridge-tamped. The slab is of composite construction; precast soffit panels 3in thick span between the secondary beams and are covered with 2in of *in situ* concrete. Bond with the main and secondary beams is further helped by "Tentor" reinforcement projecting from the panels. The *in situ* topping has mesh reinforcement. Floor slabs were placed by the crane used for the secondary beams and, in some cases, by a "Reema" erection derrick in the middle of the building.

For the remainder of the ground floor—that is the 39ft 6½in wide end bay at the front of the building which serves as the showroom—main beams of the same size span across the width of the bay at right angles to the main beams over the other bays. The beams are also carried on independent columns in order to reduce the transmission of noise from the rest of the structure into the showroom.

Roof Construction

The main roof beams are of I-section with an overall depth of 3ft 4 in; they were precast in 15ft lengths. At this level the central suspended portion of the centre span is reduced to 41ft 2in and the cantilevers are increased accordingly. Diaphrams cantilevering 5ft 9in on each side of the main roof beams at 15ft intervals, form the haunch section of the precast secondary beams. The main roof beams were assembled on the finished first floor slab, beneath their final positions. Two of the three cables in the cantilevered beams, and all the cables in the suspended spans, were stressed before the beams were lifted into position. Erection was by means of a single erection mast.

The diaphragms which project from the main roof beams carry the suspended double-cranked central sections of the secondary beams. These sections are 31ft 2in long over the two end bays and 29ft 1in long elsewhere. At the ends of the building each external column has a cantilevered head which projects 3ft 9in to form a halved joint with



Details of two-storey structure in prestressed concrete. The main roof beams are not shown in detail; they are generally similar to, though somewhat lighter than, the first floor main beams shown in the lower three views

the secondary beam; these columns were precast and prestressed. All other columns in the building are of *in situ* concrete.

The maximum depth of the secondary beams is 2ft at the haunches and the minimum is 1ft 6in at mid-point of the suspended spans. The profile of the cranked beams has been so arranged that a single prestressing cable, anchored at the external columns, could be used for the full 200ft length of the building. The ends of each section of the secondary beams are halved, so that suspended portions can rest on haunch sections without temporary supports. To erect a complete secondary beam, the sections were first positioned along the whole length of the factory; next, caulked mortar pressure pads were formed in the top half of the halved joints; the cables were then threaded and tensioned; and finally the bottom halves of the joints were filled with mortar. The joints are situated in regions of one-way bending; this method of construction has resulted in a series of continuous beams which have been stressed in a determinate condition.

Precast reinforced concrete purlins support the roof cladding which is wood wool slabs covered with bituminous felt. Welded steel frames for the monitor roof lights are bolted to the secondary roof beams.

Concrete Specifications

All concrete above ground floor level was specified as a nominal mix of 1 : 1½ : 3 by weight. The *in situ* concrete was specified with a water to cement ratio of 0·43 and a minimum 28-day cube strength of 6000 lb per square inch. The actual cube strengths ranged between 7000 lb and 8000 lb per square inch. The concrete for the precast units was specified with a water to cement ratio of 0·40 and a minimum 28-day cube strength of 7000 lb per square inch. The actual cube strengths ranged between 8000 lb and 9000 lb per square inch.

The mortar for jointing was made with equal parts of sand and rapid-hardening Portland cement mixed with the minimum amount of water required to give cohesion. This mortar was caulked hard into the joints. Normally stressing was not started until two days after completion of the last joint. Where the initial stresses were low, this period was reduced to one day. "Conbex" grout was used.

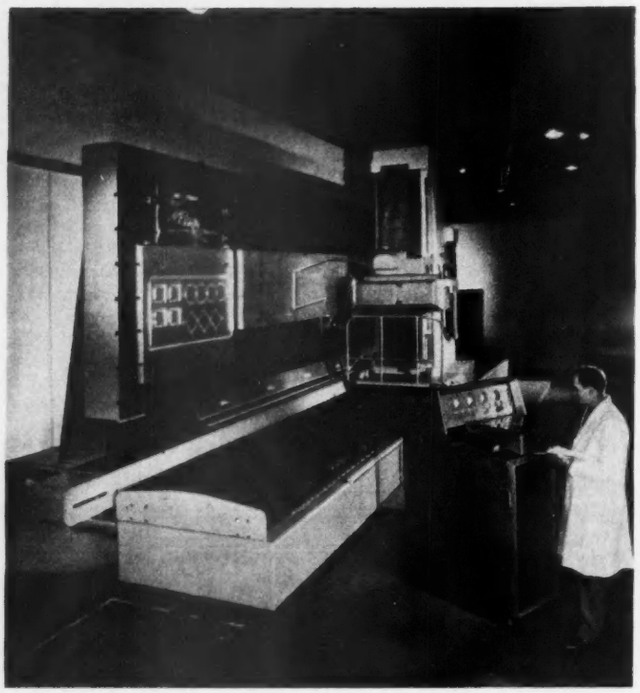
The maximum bending stresses in the concrete are minus 100 lb and plus 2250 lb per square inch. The maximum principal tensile stress is 100 lb per square inch. The final steel stress after a total relaxation of 15 per cent is 60 tons per square inch, or 60 per cent of the ultimate strength of the wire. The loss of prestressing force in the pretensioned beams was taken as 20 per cent. This force was ignored in the calculation of the shear conditions at the supports of these beams because of the very short transfer length available.

The building was erected for R. F. Seward, Southampton. The consulting engineer was Mr. E. W. H. Gifford, M.I.C.E., the general contractor Sadler and Co., and the subcontractor for the concrete frame Reed and Mallik, Ltd.

Cold Casting Metal.—A cold casting metal known as "Metolux" is now available from M.G. Plastics, Ltd., 9, South Molton Street, London, W.1. This material is a liquid consisting of thermosetting plastics which, when mixed with a powder incorporating finely divided metals, supplied in a separate pack, forms a mouldable paste. This paste on setting is stated to possess all the desirable properties of a solid metal. The metal when set is stated to withstand temperatures up to 450 deg. Fah., and it can be finished to shape by filing or sanding. It can be used to patch or fill holes in all metals, including aluminium and its alloys, as well as in connection with wood, canvas or fibreglass.

Engine Oils.—Multigrade oils of viscosity 10W/30 have now been added to the Shell "Rotella" range, using the same heavy-duty additives and a solvent-extracted base. A Supplement I grade, designated by the suffix "T," is also available.

Electronically Controlled Milling Machine for Aircraft Components



An electronically controlled machine for the three-dimensional milling of aircraft components from slabs up to 8ft high by 25ft long has been developed and built by the Fairey Aviation Company, Ltd., in conjunction with Ferranti, Ltd. This machine, which can be seen on the right, has completed rigorous acceptance tests, and so far its production rates are from ten to thirty times faster than with the conventional methods in machining aircraft components from large slabs.

PARTICULARS have been received from the Fairey Aviation Company, Ltd., of a three-dimensional milling machine, equipped with the Ferranti electronic programme control system, which has been developed and built for the manufacture of machined integral aircraft components from slab material. This machine has a table capacity for slabs up to 8ft high and 28ft long, and is designed for machining speeds of up to 150in per minute. It was designed and built by the Fairey Aviation Company, Ltd., in conjunction with Ferranti, Ltd., after an extensive research and development programme had been carried out by the former company into the manufacture of slab components.

In the initial investigations on high-speed cutting of light metals the problem of metal pick-up and welding to the cutter was resolved by injecting oil mist directly on to the cutting face from jets embodied in the cutter. A drive system was developed in which a rack drive gearbox had two gear trains driving in opposition and incorporated a preloading device which eliminated backlash independent of gear tooth clearance. A slide system with extremely low co-efficients of static and dynamic friction and free of stick-slip was also developed, as well as a structural design incorporating high mechanical stiffness with a minimum mass.

Various programme control systems were investigated, and it was decided that the most suitable would be the Ferranti digital system in which a computer is used to process the planning information, the machine control equipment being simply a servo system utilising, as its input, the magnetic-tape-recording produced by the computer. For the measurement system there has been adopted optical diffraction gratings which are completely independent of the drive system and measure movement of the slides directly, thereby embracing the complete machine within the control loop.

With its knowledge of the requirements of the aircraft industry Fairey therefore prepared a scheme for a machine tool capable of utilising the full control possibilities of the Ferranti system, a machine to have a high degree of accuracy and to be at the same time an efficient cutting engine, thus making integral construction an economic proposition. This scheme had been made possible through a proposal which had been put before the Aircraft Production Development Directorate of the Ministry of Supply and had received its support. A development contract was issued in late 1955 for the design and manufacture of the machine, and it provided for full-scale testing of the various unorthodox ideas to be progressively done throughout the construction programme and continued until the machine was completed, when it would be subjected to a comprehensive series of performance tests.

The machine, which can be seen in the illustration in this page, weighs 50 tons and has a vertical column with a travel of 25ft along the bed, this forming the x axis of the machine. Mounted on the face of the column is the head carriage which travels vertically along the y axis over a distance of 7ft. The cutting head is fixed to a cross-slide on the head carriage and has an infeed movement of 12in along the z axis. These x, y and z movements are servo controlled from the pulse information recorded on the magnetic tape.

The vertical worktable of the machine is 8ft high and 28ft long and is built up of four 15in deep cast iron slabs mounted on three buttress supports. These supports stand on base castings fastened to the machine bed and enable the table to be set at a suitable distance from the cutting head, this range of adjustment being 24in. Running along the lower edge of the worktable is the chip conveyor which carries the swarf to one end of the machine and deposits it in containers. A series of hinged deflector plates on the conveyor can be closed to form a walkway along the full length of the table to facilitate component handling. Slide faces and other functional parts of the machine are fully protected by flexible covers against the ingress of swarf.

The operator normally stands in front of the control desk and on the platform at the base of the column is the hand control box mounted on a hinged pedestal which can be used for manual operation of the machine and setting up to component datums. Two speeds are provided on each of the three machine movements, a normal operating speed for cutting and a pick-off speed at which single movements of 0·001in can easily be selected. Hydraulic and electrical power supply equipments are enclosed in a separate housing away from the machine. The electrical cables and air supply lines are brought into the column on an overhead boom hinged from a wall stanchion, and the hydraulic oil supply passes through flexible pipes encased in armour sheathing rolling in a metal trough built along the front edge of the bed. The weight of the head carriage is balanced by means of a hydraulic cylinder inside the column.

The traverse speeds on the machine are infinitely variable up to the maximum of 150in per minute on x and y axes and 75in per minute on z axis. The normal operating range used in production is 100in to 150in per minute for the roughing operations and 50in to 75in per minute for the finishing operations.

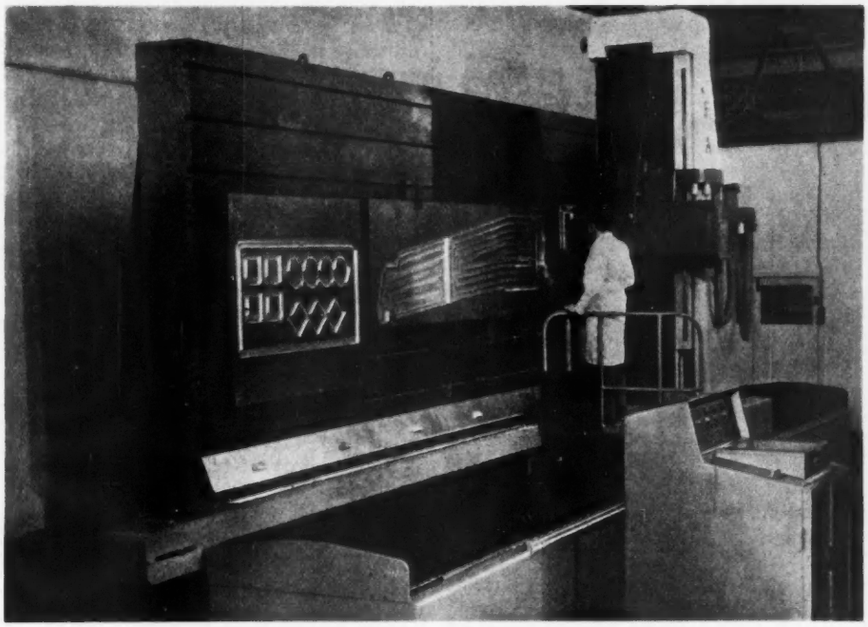
The method of slide lubrication used is a version of the hydrostatic pressure system, in which the moving members are entirely supported on an oil film with no direct metal-to-metal contact between the bearing faces. An automatic metering device controls the pressure of the separating oil film in such a way that external loads applied to moving members cause an opposing force system to be set up in the oil film to balance the loads completely and maintain the location of the slide. The system thus accommodates all the cutting and inertial loads encountered, and the frictional forces are entirely viscous and independent of the loads on the slide. The main bed slide of the machine under test with a 9-ton load gave the following relationship between friction force and speed :—

At 10in per minute, force required = 2 lb ; at 100in per minute, force required = 20 lb ; at 200in per minute, force required = 40 lb.

A reduction of the load from 9 tons to 1 ton caused a slide movement of only 0·0003in from the mean setting, the carriage still floating freely. This system is virtually free from wear, there being no metal-to-metal contact, and so the accuracy and efficiency of the slides should be maintained indefinitely.

The Drive System

It is not uncommon in a conventional machine tool drive system to find that the drive motor can be turned through a number of revolutions before the machine begins to move, due to backlash between the mating teeth of the gearing and wind-up or elasticity in the gear shafts and bearings. Naturally, if a controlled machine tool is to follow the control information with any degree of accuracy, then these conditions must be eliminated. The drive system adopted for this machine is by high-speed hydraulic motors of extremely low inertia coupled to specially designed gearboxes. A Ferranti



Programme-controlled, three-dimensional machine for milling aircraft components from slabs up to 8ft high by 25ft long

standard ½ h.p. gearbox used on the infeed movement drives on to a recirculating ball lead screw engaging with a double-nut system with spring preload.

The larger gearboxes on the *x* and *y* movements are of Fairey design and are twin-train boxes terminating in a pair of spur pinions driving on to a common rack. The gear loop is closed at the input end by an axially floating shaft with right- and left-hand helical pinions engaging with the first gear in each of the two trains. Pneumatically loaded bellows apply an axial load to the floating shaft which results in a preload torque equal to 110 per cent of full-load torque being applied throughout the two trains. Under conditions of no-load the preload torque is equally distributed through the two gear trains and it is taken up by the driving train as the drive torque is applied. At full load the remaining 10 per cent of the preload exerted on the non-driving train maintains the backlash-free condition. The axial float of the preload shaft accommodates any tooth ripple or eccentricity errors in the gearing and, over a period, automatically takes up tooth wear.

The gears, shafts, bearings and mountings were designed for optimum conditions of high stiffness with low inertia and it is stated that, due to these considerations, combined with the virtual absence of slide friction, the resonant frequency values recorded on test were: for the *x* drive with an 8½-ton column, 22 c/s, and for the *y* drive with the 1-ton vertical carriage, 63 c/s.

The 20 h.p. cutting head runs at 6000 r.p.m. and has been tested on the machine up to metal removal rates of 140 cubic inches per minute for face milling and 110 cubic inches per minute with end mills of 2in and 3in diameter. The surface finish obtained at these rates was around 10 micro-inches r.m.s.

The Control System

The system of control was fully described in an article in The Engineer of April 13, 1956 (page 326).

Along the length of each axis of the machine is a glass grating, ruled over its full length with a pattern of fine dividing lines spaced with a frequency of 500 lines per inch. On the moving member there is a reading unit with a small section of similarly ruled grating which, placed at a slight angle to the long grating, sets up a Moiré fringe pattern where alternate dark and light bands travel across the screen each time a line is passed. A group of photo-cells scan this fringe pattern and transmit two pulses for each line counted, so that each pulse represents a distance of 0·001in.

Considerable emphasis has been placed on electronic reliability and the circuits are designed to continue functioning correctly even if the value of any of the components varies by as much as 30 per cent. As an additional precaution, a daily check drill is instituted where the screen voltages of all the valves in each channel are reduced in turn, so that any component approaching the marginal condition can be replaced before the day's work commences. This marginal check occupies only ten to fifteen minutes, but the reliability of the equipment is such that it has never been found necessary so far to replace any components. Checking circuits are provided to ensure that the errors in the machine movements never exceed a preset level. The check channel pulses from the tape are compared with the sum of the feed-back pulses from the *x*, *y* and *z* gratings and if the discrepancy between these exceeds eight digits, the machine stops. In addition to this, safety interlocks are also provided to stop the machine in case of failure of any of the services. Several refinements have been added to the control equipment supplied for this machine. The code symbol MCC-F appearing on a programme will automatically switch the control circuits to double pulse scale, where traverse speeds of over 75in per minute are being used and at the end of each programme the symbol MCC-W is used to stop the tape-deck. A mirror image switch has also been added to the control desk so that right- and left-hand components can be produced from the same magnetic tape.

Performance

A comprehensive acceptance programme was devised by the Ministry of Supply to test every aspect of the machine performance. A full alignment check was made and a series of test pieces machined and inspected for accuracy and finish. Time trials were conducted under full cutting load and complete functional checks made on all services. Extremely good surface finishes were obtained even under full load conditions; 8–10 micro-inch r.m.s. at 110in per minute, with a 3in diameter end mill on a full face cut at 0·34in depth is a typical example. Dimensional accuracies of ±0·002in were achieved on dimensions up to 18in with repeatability within 0·001in over four consecutive test pieces. An elliptical channel section frame 7ft high, which entailed the machining of four elliptical paths, was produced with every dimension within 0·005in, the part being programmed directly from the curve equations. All the test pieces were machined at the normal traverse rates quoted above.

The makers state that it is too early yet to quote actual production times against conventional machining times, as the few components machined have not been produced in sufficient quantity by hand methods to achieve a settled production time. The time saving in relation to these is, of course, extremely high, but records being compiled indicate, so far, that the original estimates of production rates between ten and thirty times faster than normal will be borne out.

Development work under the Ministry specification is still proceeding on various aspects of the machine. Specially designed bearings will soon be ready for test for use on a 100 h.p. spindle to operate at 12,000 r.p.m.—which will raise the cutting capacity of the machine to 500 cubic inches per minute or even higher. Various aspects of angular control are being studied, the farthest advanced of these being a spindle adaptor carrying a variable angle cutter which will mill the changing angles normally encountered around the periphery of wing ribs. This can be achieved without any additional control equipment by locking the infeed movement and switching the "Z" channel over to the angular control. Design studies are also under way for a smaller version of the machine, for milling high tensile steel components.

Fireproof Insulation Board.—A fireproof insulation board, known as "Ubesto," being made by the Universal Asbestos Manufacturing Company, Ltd., Tolpits, Watford, Herts, is stated to be an entirely incombustible panelling board. It is grouped in Class 1 under B.S. 476, 1953, and has a high degree of resistance to direct flame impingement. This low-density board, with a high asbestos fibre content, conforms with the requirements of B.S.S. 1785, its thermal conductivity or "K" factor being 0·80. It is of entirely mineral composition and is rot- and vermin-proof. Water absorption of the board is stated to be 80 per cent of its own weight, without structural deterioration, when immersed for twenty-four hours. It is made in three thicknesses—¼in, ⅜in and ½in—with approximate weights of 1 lb, 1 lb 6 oz and 1 lb 13 oz per square foot respectively.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

RAILWAYS INTO ROADWAYS

SIR,—When I write of Mr. Torbell's dream railway, described in your issue of April 25, it is without irony. Even the push-button railway visualised by Mr. Ward, in your issue of April 4, must be recognised as practicable. It is valuable to have these pictures of the ultimate in railway operation. There is, however, one thing lacking : the clients and customers of the era have been left out of the dream. For instance, the stations of all but very few of the intermediate towns on Mr. Torbell's line are to be closed : their townsfolk will be deprived of a service, and a most valuable strip of real estate, paying no rates or taxes, bisecting these towns, will be used exclusively by other people and their goods in trains thundering through at top speed, day and night, to which there may be some local reaction. That may be rated only a minor point ; but what of the general attitude towards the new, dream services ? The primary factor in transport has been defined by the General Manager of the Southern Region in an Institute of Transport lecture : it is a very human one ; people in industry persist in putting their own convenience first ; they require transport to be prompt and punctual, ready to go anywhere —in a word, obedient, normally written flexible. As a prelude to offering dream services more inflexible than the present services, Mr. Torbell decries flexibility ; but the indications are that people and industry will go their own sweet way, preferring road transport, irrespective of Mr. Torbell's lament, unless the secondary factors in his services outweigh convenience. These are price and speed, but they come only a very poor second to personal and industrial convenience, with safety almost nowhere (being extant to a satisfactory degree in all common forms of transport). Accordingly, even if streamlining and push-buttoning lead to more than a marginal cheapening and speeding of rail transport—which seems improbable—there is little chance of reversing the present steady drift of traffic away from the railways. That is substantiated by the experience of the U.S.A., where £5000 million has been spent post-war on modernising railroads, even up to a standard not far short of Mr. Ward's ideal. Indeed, the desperate situation of the American railroads, revealed in their own evidence before the Land Surface Transportation Sub-Committee of the Senate in Washington last February, is an object lesson for Britain. The drift away is gathering speed even in the country of the long haul. Railway modernisation, dreamed onwards to the limit, cannot be relied upon to satisfy human and industrial needs.

Admittedly railway conversion also is a dream. The great difference is that it is the dream, not of professional transport operators, but of ordinary, thinking men and women of Britain—transport's clients and customers and amateur practitioners—of whom the League is just a cross section. You will appreciate that some little time must elapse before the League reacts to the stimulating leading article in your issue of April 25. Meanwhile, since you have allotted it an expensive task, I wonder whether you would graciously allow me to add that it is a non-profit organisation, managed by a committee of twenty-two, and that donations and applications for membership or associate membership should be addressed to the Secretary, Railway Conversion League, 123–124, Newgate Street, London, E.C.1.

T. I. LLOYD

Railway Conversion League,
London, W.9,
April 28, 1958.

SIR,—May I draw attention to fundamental errors of fact in Brigadier Lloyd's letter, published in your issue of April 11, which in my submission invalidate much of his argument ?

First, although Brigadier Lloyd questions Mr. Spencer's argument on coal traffic, he himself quotes, in reference to such traffic, figures which are largely irrelevant. For instance, he writes (specifically in respect of coal) of the average trainload as being only 159 tons. This is actually the average trainload for all classes of freight traffic, including merchandise, which on average weighs much less in relation to wagon-space occupied. The figure for an average coal trainload is very much higher, and, indeed, the actual trainload on many routes, like that over the Pennines between Wath and Godley, is 500 tons or more.

Next, your correspondent's contention that " a single 20-ton " (road) " tipper could do the job " (of a 1000-ton train) " in four days," would appear to involve one lorry driver having to work continuously for 100 hours to a schedule of two runs (one in each direction) at 60 miles in the hour for each of fifty round trips (i.e. 56 miles each way). A more realistic appreciation of the manpower involved (for one vehicle) would be four men per day (if they could stand the strain of operating at the speed envisaged), while even this estimate disregards those who build and maintain the vehicle, and the way, and those who police it, and also those who administer the transport service. Of the fifteen men mentioned by Brigadier Lloyd as necessary to operate one train, only three are concerned in moving a particular freight train. The remainder include such as signalmen, maintenance, workshop, clerical and other staff. Brigadier Lloyd's further argument, that " roundly, British Railways employ 600,000 people to run daily 40,000 trains " is equally fallacious. The actual total of less than 571,000 (not 600,000) British Railways employees includes about 20,000 staff who are engaged solely in collection and delivery work by road. Within the overall total there are also more than 126,000 workshop staff, responsible for the construction of a considerable proportion of British Railways rolling-stock, and for the maintenance of all of it. But in nearly all Brigadier Lloyd's arguments and examples he refers, on the road haulage side, only to drivers.

In the third paragraph of his letter from which I quote, however, he does tell us that the number of transport employees in the country (including B.R.) is about 2,000,000. But British Road Federation statistics (Basic Road Statistics) show that there are 2,050,000 employed full time in road transport alone ! To this should be added the clerical administrators of more than 1,000,000 " C " licensed vehicles, and at least the drivers of some 4,200,000 private cars, of which over 1,000,000 are generally acknowledged as " business." It is thus clear that there are some 4,000,000 persons actively engaged in transport, a figure which puts in proper perspective the 570,000 employed by British Railways. Brigadier Lloyd goes on to ask if we are " justified in perpetuating so dangerous an industry " (as the railways) " imperilling fully 1 per cent of the entire population, when there is an existing alternative ? " Evidently the Brigadier has not compared the published figures of rail and road safety or he would not ask such a question. In 1956 (the last year for which the Ministry of Transport official statistics have been published) 171 railwaymen of all grades were killed (0·0000034 of the population), and (from all causes including trespass and suicide) 289 other persons. In the same year, there were 5267 deaths caused by road usage, including 533 drivers. In fact more than one-half of one per cent of the population were killed or injured in road accidents in 1956.

J. H. BREBNER

British Transport Commission,
London, N.W.1,
April 25, 1958.

SIR,—I was surprised to note in your leader of April 25 that you take the attitude that Brigadier Lloyd should be expected to produce further evidence in support of his proposals for railway conversion. I submit that he has made out a prima facie case for investigation on the basis of the following facts :

(1) In six years' time, traffic on our roads will have doubled, and will result in a state of chaos, a situation which no official plan yet proposed can possibly alleviate.

(2) World-wide statistics prove that the traffic capacity of a road is far greater than that of an equivalent width of rail track, operating conditions being equal.

(3) The roads of this country carry four times as much traffic as the railways.

(4) The bulk of the road traffic is carried on approximately 20,000 miles of route, which is open to every kind of vehicular and pedestrian traffic, littered with obstacles, intersections, gradients, bends and every conceivable kind of restriction. Of these roads, only 1 per cent exceed 40ft in width and 10 per cent exceed 30ft.

(5) The railways carry only 20 per cent of all the country's transport.

(6) The railway system comprises 20,000 miles of segregated routes from which all other forms of traffic are excluded. These routes have completely unobstructed passage into the heart of every big town in the country. Of these routes, 10 per cent exceed 40ft in width and 50 per cent are at least 30ft wide.

(7) It is completely impossible to envisage any new road system which could duplicate these routes.

(8) Railway conversion would completely solve our traffic problems, and would cost much less than the sum already destined for rail and road development, which expenditure will not touch the fringe of the real problem.

Before insisting that Brigadier Lloyd, at his own expense, should shoulder the responsibility of officially appointed and publicly financed bodies and do their job for them, I would challenge his critics to prove beyond doubt :

(*a*) That his proposed scheme is unworkable, or that it would not, as he claims, solve our traffic problem.

(*b*) That the present railway and road improvement plans will significantly reduce the increasing chaos on the roads.

(*c*) That there is any alternative means by which 20,000 miles of comparable motorway can be made available.

In passing, I should like to refer to the letters of Messrs. Torbell and Trillo. Both these gentlemen attempt to beg the question by comparing the best conditions of rail travel with the worst conditions on the road. Let Mr. Torbell get his imagination to work on the effect of rail accident figures, were we to remove all pedestrian and slow vehicular traffic from the roads and allow it to wander at will over the railway track ! As for chaos in fog, Mr. Torbell should know that even with our present inadequate road system, long-distance road transport still seems to deliver its loads under fog conditions more quickly and dependably than the privileged railways. Mr. Trillo, I suspect, is a back-seat driver who has evidently not read "Twilight of the Railways," or he would not seek to make invidious comparisons between existing road conditions and the high standard of comfort and safety envisaged on converted railways.

May I, in conclusion, express my admiration for the great service which you are doing in giving space to discussion of this vital subject.

L. M. BALLAMY

Guildford,
April 30, 1958.

A "TIDDLEY" BUDGET

SIR,—I am surprised that in your editorial comment under the above heading in your issue of April 18, you made no reference to the Chancellor's concession on the subject of professional subscriptions paid by tax-payers assessed under Schedule "E." If this concession reaches the statute book substantially in the form in which it has now been embodied in the Finance Bill, a long-standing grievance of the majority of professional engineers who have in the past not been allowed to deduct the subscriptions to their Institutions as expenses against income tax will have been eliminated. The concession is one which the engineering profession will enjoy in common with the other learned professions, and it may be of interest to your readers to know that in the discussions between the Inland Revenue Authorities and representatives of these professions, out of which this concession has emerged, the engineering profession was represented by the Engineers' Guild, being the only body qualified in such circumstances to represent "the profession, the whole profession and nothing but the profession."

The subject of professional subscriptions and Schedule "E" assessments is one which has exercised the Engineers' Guild for a number of years and articles on the subject by Mr. Wilfred T. Fry, Income Tax Consultant, are to be found in the issues of the Guild journal for November, 1948, and May, 1950.

It is to be hoped that with this tangible evidence before them of the importance of having such a body to represent the engineering profession in such matters, a larger proportion of that profession will now consider taking up membership of the Guild than have done so to date. For very many of them the Chancellor's latest concession will at least pay their annual subscription to the Guild.

Southampton, J. H. JELLETT
May 2, 1958.

Book Reviews

The Channel Tunnel. By HUMPHREY SLATER and CORELLI BARNETT. Allan Wingate (Publishers), Ltd., 12, Beauchamp Place, London, S.W.3. Price 21s.

Now that an agreement has been reached between the Egyptian Government and the Suez Canal Company about the compensation to be paid for the nationalisation of the canal there exists an international company with substantial capital but little to control ! In these circumstances to judge by quite recent events the shareholders in the company may very well like to study the economics of building a Channel Tunnel. For, even before Nasser nationalised the Suez Canal in 1956, the company had been looking around, aware that its canal concession ran out in 1968, and aware therefore that some other project must subsequently become its interest. There are, of course, other interests in the field, but last year it appeared that all had come to an agreement about their shares in such an enterprise and a report by a well-known firm of British consulting engineers has recently been made.

These circumstances make the appearance of this book peculiarly welcome. For it traces the whole history of the Channel Tunnel, which has been discussed and argued about for over a century, which four or five times has appeared to be on the verge of actual construction and which was in fact once actually begun. Always, however, its construction has been opposed by the brass hats of the British Army. In recently opposing the building of the tunnel Field-Marshal Lord Montgomery was following the line successively taken by Sir Garnet Wolseley in the 'eighties, Sir Redvers Buller as the twentieth century began, and the Committee of Imperial Defence in 1930 ; not to speak of Lord Wellington who is said to have resisted the construction of a railway between Portsmouth and London on the ground that it would facilitate invasion from the Continent. Perhaps in a year or two's time construction will at last be begun and pushed forward to completion—perhaps not !

The book is less technical than popular. But it contains enough of a technical nature to hold an engineer's interest. The whole style of writing is lively and the reader is introduced to numbers of people with entertaining characters who have successively been attracted as engineers to attempt the solution of the technical difficulty of building the tunnel, or speculative enough to consider it worth while risking their own or other people's money on trying to build it or even to get permission to build it. As engineers we should like to see it built. For even if, as seems probable, there would be little technical difficulty in actually boring it there are some awkward problems to be solved in ventilating it, more particularly if road transport were to use it. But the real decision we suppose depends on economics. But what a peculiar consequence of Nasser's seizure of the Suez Canal it would be were an undersea crossing between Britain and France constructed !

Engineering Materials Handbook. Edited by CHARLES L. MANTELL, Ph.D. McGraw-Hill Publishing Company, Ltd., 95 Farringdon Street, London, E.C.4. Price 167s.

IT is stated that the need for this reference work on engineering materials arose from a graduate course in technology of engineering materials which was conducted by the editor at the Newark College of Engineering in the United States. It is a collective work of more than 150 specialists and authorities on the materials covered, and many of the contributors are lecturers for the course at Newark College. The materials covered in the forty or more sections into which the book is divided are considered from the viewpoint of engineering structures and equipment. Emphasis is placed upon the fabricated forms of materials, their physical and mechanical properties, their adaptations, advantages, limitations, competition with each other, and protection.

The subject matter falls into four main parts, the first of which covers the production fabrication properties, applications and other information on metals—cast iron ; steels ; non-ferrous metals ; uncommon, precious and special metals ; metals used for electrical purposes ; and powder metallurgy. The second group of sections deals in detail with inorganic materials—clays, refractories, silicas, glass, stone, concrete and the like. Organic materials covered in the third part of the book include tars, pitches, waxes, paints, rubber, plastics, and silicones. The last part of the book is devoted to the various aspects of permanence of materials in service, their corrosion, deterioration, protection, and the causes and prevention of failure.

It is not easy to give more than a general impression of the wide scope of an encyclopedic volume of this kind in a reasonable space. It can be said, however, that in making random checks of a variety of materials and points of interest in fabrication, properties and so forth of a number of the generally known, as well as some less familiar materials, the information given is concise and sufficiently complete to satisfy most requirements. A bibliography at the end of each section gives the user guidance to literature containing more details on particular subjects on which he requires further information. These individual bibliographies are supplemented in the final section of the book which covers sources of information on engineering materials in American literature. The volume concludes with an excellent index.

Tightening and Tensile Tests on Joints

By J. E. FIELD*

No. II—(*Concluded from page 658, May 2*)

The static strengths of B.S.W., B.S.F., UNC. and UNF. bolt-nut combinations have been compared under various conditions of tightening, with a particular view to checking the suitability of UNF. threads for general use. Tests were carried out under single and repeated tightening, and some of the nuts were bored out to simulate conditions resulting from the use of an oversize tapping drill. While the UNF. combinations were at least as strong as the others for a single tightening, many of them failed by thread bending and stripping and they were not so resistant to repeated tightening as the others. For satisfactory use of UNF. combinations, tightening must not be sufficient to cause yield. It is suggested that UNC. threads would generally be preferable in heavy applications where close control of tightening is not possible. In changing over from Whitworth to Unified threads, each case should be considered on its merits, and UNF. should not be taken as an automatic replacement for B.S.F.

Development of Clamping Load

IT will be seen from Tables II to IV (*ante*) that the separation loads (column 10 and column 14 in Table III), after a single pre-tightening to a given percentage of maximum failure torque, were not lower for the UNF. than for the other types of combination. This should also apply to the initial clamping loads developed on tightening, since

$$\frac{P_i}{P_s}=\frac{K_M}{K_M+K_B}$$

where

P_i = initial clamping load.
P_s = joint separating load.
K_M = stiffness of clamped members (load per unit deflection).
K_B = stiffness of bolt (load per unit deflection).

The same joint adaptors were used throughout, for a given size of bolt, and K_B would not vary much as between the different types of bolt in a given size. An indication of the efficiency of an assembly in developing clamping load may thus be obtained by dividing the torque applied by the load for joint separation (column 7 to column 10 and column 11 to column 14 in Table III). Assemblies with the higher values of torque per ton of separating load will be the least efficient. In this respect no type of combination shows up consistently better than the others over the whole range of sizes. This is not surprising, in view of the fact that only about 10 per cent of the total applied torque is effective in producing tensile load in the bolt ; the remainder is used, in roughly equal amounts, in overcoming the friction in the threads and at the bearing face of the nut.[5] Any variations in these frictional forces will thus tend to mask those due to differences in thread form and pitch. Heavy thread deformation occurring prior to failure by stripping may cause the thread friction to increase rapidly, and maximum failure torque would then not be a reliable guide to the clamping load developed.

An attempt was made, by making measurements of bolt elongation under given loads, and when tightened under a given torque, to estimate the stiffness of the joint adaptors and the actual clamping loads developed. The results, however, were not very consistent. It appeared that, for the ¾in combinations, a joint separating load of 10 tons indicated an initial clamping load of about 8 tons. An interesting secondary result emerging from measurements made in this connection was that, for these 3in long, ¾in diameter combinations, the deflection of the bearing face of the nut, relative to the bolt at that point, was of the same order as the elongation of the bolt itself. This means that, in assessing the effective stiffness of a bolt, the nut deflection should not always be ignored, as it usually is.

* Mechanics and Materials Division, Mechanical Engineering Research Laboratory, East Kilbride.

Tensile Failure Loads

The loads for tensile failure were not significantly affected by pre-tightening. This was to be expected, as the joint separated before failure in all cases and any frictional torque would have been released by slight rotation of the joint adaptors in the tensile testing machine. For a single pre-tightening, the tensile loads for failure of the UNF. combinations compared favourably with those for the other types (Tables II to IV, column 8, and Table III, column 12).

Yield and Failure Torques

The ratio of yield torque to failure torque was lowest for UNF. in all three sizes (column 2 to column 3). For the ⅜in and ¾in sizes, this ratio decreased over the four types in the following order : UNC., B.S.W., B.S.F., UNF. For a given type of combination the ratio decreased as the size increased, i.e. for the cases investigated, as the D/p ratio increased. Some engineering handbooks give tables of failure torques as a guide to " safe " tightening torques for various kinds of combination. The results show that it is not possible to specify a fixed " safe " percentage of failure torque for all types of combination, or even for different sizes of any one type, without being unduly conservative in the case of relatively coarse threads (low D/p ratio).

Repeated Tightening Tests on Normal Combinations

The results of Table V on ¾in combinations have been reported in detail to indicate the variations which can be obtained for successive tightenings of the same assembly. It will be seen that the breakloose torque (maximum unscrewing value) in all cases, and the tightening yield torque in about half the cases, decreased markedly after the first tightening but did not undergo a further definite decrease on subsequent tightenings. There was sometimes a marked change after dismounting and reassembling for the sixth to seventh tightenings, but this change was not in the same direction in all cases. The average yield torque after the first, and after the sixth tightening, both differed appreciably from that after a single tightening as given in Table III. These observations have an obvious relevance to the use of " standard " torque-tension relations in practice.

By comparing Table V with Table III, column 10, it can be seen that the joint separating loads after the sixth tightening were in all cases markedly higher than those after a single tightening. This is no doubt partly or wholly due to decrease of friction owing to repeated rubbing down of high-spots, resulting in a greater proportion of the applied torque being available to develop clamping load. Some of the increase in separating load may have been due, in the B.S.W. and B.S.F. cases, to increase of tightening torque applied, but for UNC. and UNF., the torques applied on the sixth tightening in Table V were actually lower than those for a single tightening (Table III, column 7), though producing higher separating loads than in the latter case. As the most marked change in yield and breakloose torques occurred after the first tightening, it seemed that this might also apply to joint separating load. A few tests were carried out out on ¾–12 B.S.F. assemblies to check this. Three combinations were each tightened twice to the average value of yield torque as given in Table III, column 2 (3210 lb-in) the joint separating load being determined after each tightening. One of the combinations yielded before the tightening torque was reached and two did not. The average joint separating load after the first tightening was 11·2 tons, and the increase of separating load after the second tightening was respectively 0·7, 0·7 and 0·8 ton. These relatively small increases indicate that the joint separating load increases only gradually after each tightening and not mainly on the second tightening, when a given torque is applied to the nut.

Effect of Multiple Tightening

In order to check the effect on clamping load of a relatively large number of tightenings, the tests reported in Figs. 2 to 5 were carried out on three combinations of each type, using a procedure similar to that for the Table V tests, except that a much greater number of tightenings was applied, in each case until the occurrence of yield, i.e. of appreciable plastic deformation. It is evident that the number of tightenings to yield, which could be withstood before failure, decreased with the pitch of thread. The ten T.P.I. threads, i.e. UNC. and B.S.W., required about the same torques up to about fifty tightenings, after which the torques for UNC. were somewhat lower than for B.S.W., though the clamping loads were as high, and the number of tightenings to failure greater, than for B.S.W. This difference in behaviour was similar to that observed in the Table V tests.

The B.S.F. combinations withstood only about half, and the UNF. combinations only about one-quarter, of the number of tightenings sustained by the UNC. combinations, though the clamping loads developed were higher, corresponding to the higher yield torques.

Within about five tightenings from ultimate failure, there was no very serious reduction in the tensile loads for joint separation and failure for UNC., B.S.W. and B.S.F. For UNF., it appears that a rapid reduction, corresponding to progressive thread bending, set in by about the twentieth tightening, i.e. at about ten tightenings before the final one, at which thread stripping was not complete, slight clamping still being retained. This again illustrates the possibility of severe damage to a UNF. combination through overtightening, which might go undetected on assembly.

Multiple Tightening Tests to Given Torque Values

The results of the repeated tightening tests on normal combinations, using a torque spanner, are given in Table VII. Each com-

bination was repeatedly tightened to a given value of torque, instead of to yield, as in the Table V tests. The results for ¾–10 B.S.W. at 2500 lb-in tightening torque are anomalous, the damage to the bolt being similar to that produced by a tightening torque of 3500 lb-in, and greater than that for intermediate torques. It can only be assumed either that the torque spanner was not applying correct torques or that the frictional resistance was abnormally low in these tests. They were in fact made at a different time from the other tests on B.S.W. combinations, though under ostensibly the same conditions. The results are included to emphasise further the uncertainty which attaches to the use of torque-tension relations. It seems unlikely that the yield torque for these B.S.W. combinations was below 3000 lb-in, which agrees approximately with the values in Table V, but is markedly higher than the value in Table III.

Considering the rest of the results, i.e. not including those for ¾–10 B.S.W. at a nominal tightening torque of 2500 lb-in, there is still seen to be considerable variability but certain broad conclusions may be drawn.

At a tightening torque of 3000 lb-in, all four types of combination could be tightened 150 times without serious damage. Some of the bolts with coarser threads, i.e. lower core area, had, at this stage, necked down by a few thousandths of an inch, representing only a few per cent loss of load-bearing area. No appreciable thread bending occurred in any of the bolts.

At a tightening torque of 3250 lb-in, the ¾–10 UNC. combinations were liable to suffer severe necking and core failure of the bolt after relatively few tightenings. The ¾–10 B.S.W. and ¾–12 B.S.F. combinations suffered a small reduction of bolt diameter after 150 tightenings, but could evidently have withstood many more tightenings without failure. In the ¾–16 UNF. combinations, bolt necking was slight, but progressive thread bending set in at an early stage and stripping failure occurred before reaching 150 tightenings. It is evident that serious thread damage could be caused to UNF. combinations on assembly, which could not be detected by a change of resistance to tightening. Such damage might not be noticed on dismantling, especially if the threads were coated with grease. Replacement of a damaged bolt in a different nut or tapped hole, in which the threads did not match with the distorted bolt threads, would increase the damage.

At a tightening torque of 3500 lb-in the ¾–10 B.S.W. combinations behaved surprisingly well, no failure occurring although bolt necking in one case was quite pronounced. The ¾–16 UNF. combinations withstood only a few tightenings at this torque before failure occurred by thread bending and stripping. The ¾–10 UNC. combinations would evidently not have withstood this torque satisfactorily, and it seems likely that the ¾–12 B.S.F. would have behaved similarly to the ¾–10 B.S.W., judging from the results at lower torques.

It should be emphasised, however, that the higher torques withstood by the Whitworth combinations were not necessarily associated with higher clamping loads ; the contrary was in fact indicated by the Table V tests.

For reasons already mentioned, it does not seem wise to place much reliance on the torque values, and the main conclusion from these torque spanner tests is that the ¾–16 UNF. combinations were liable to fail by thread stripping after relatively few tightenings to a torque appreciably less than the average yield torque, as determined from tests involving one, or only a small number, of tightenings (see Tables III and V).

It is usual for the nut to be somewhat softer than the bolt, and yield in bending will occur in the nut threads at least as soon as in the bolt threads. Removal of a nut after such bending had occurred would involve forcing the bent nut threads over undeformed threads near the free end of the bolt ; this would cause further damage to the nut threads. Although the average value of bending stress at the thread roots does not depend on pitch/diameter ratio its maximum value is greater for fine than for coarse threads, owing to the greater concentration in the former case of the thread load towards the bearing face of the nut.[2] Fine threads would therefore yield at a lower applied load than coarse threads and this, in view of the thread deformation factor noted above, may partly account for the comparatively low resistance of fine threads to repeated heavy tightening.

Effect of Reducing Depth of Engagement of Threads

The tests with bored-out nuts were carried out because oversize tapping drills are sometimes used in order to make for easier tapping, especially in difficult materials. The results are given in Table VI and may be compared with those of Table III, for normal depths of engagement.

The differences in failure torques, Table III, column 3, and Table VI, column 2, could be due to differences in thread friction, or to differences in strength, or to both of these factors. The higher yield and failure torques for the B.S.W. and B.S.F. combinations with bored-out nuts, as compared with normal combinations of these types, were very probably due to increased thread friction ; these combinations all suffered core failure of the bolt, outside the nut, and extra torsional stresses due to increased friction could only have reduced the tensile load for failure (developed by tightening). This is confirmed by the fact that, on boring out the nuts, there was, for B.S.W. and B.S.F., an increase in the torque required per ton of separating load (for a single tightening to 75 per cent of failure torque for normal combinations : Table VI, column 4/column 7, as compared with Table III, column 10.) The torque per ton of separating load was only slightly increased for UNF., and definitely decreased for UNC. This probably means that the low failure torque for the UNC. combinations with bored-out nuts was largely due to a decrease in thread friction as compared with normal combinations. That this should occur for UNC. and not for B.S.W. is difficult to explain, but it will be remembered that the repeated tightening tests on normal combinations (Table V and Figs. 2–5) gave indications of lower thread friction for UNC. than for Whitworth threads. The tensile failure loads for the combinations with bored-out nuts (Table VI, column 5) were somewhat lower than for the normal combinations, but the difference is only sufficient partly to explain the lower maximum failure torque for UNC.

As already implied, on boring out the nuts, there was a small decrease of joint separating load for a given degree of tightening in all cases except for UNC., where there was an 8 per cent increase. On the other hand, the separating load after the sixth and seventh tightenings (Table VI, columns 8 and 9) showed a definite increase over that after the first tightening for B.S.W. and B.S.F., but not for UNC., though the latter still required the highest separating load after the seventh tightening. The UNF. combinations could not withstand even a few tightenings to 75 per cent of failure torque for normal UNF. combinations and the tightening torque had to be reduced to below 3650 lb-in (the average torque for yield of normal UNF. combination), before failure was completely avoided on the seventh tightening. At a tightening torque of 3210 lb-in, however, which was the highest 75 per cent value for any of the other types of combination (viz., for B.S.F.), seven tightenings could be successfully applied, and the tensile separating load was then rather higher than for B.S.F., tightened to the same torque, although lower than for the UNC. combinations, which were only tightened to 3100 lb-in.

The stripping failures of the UNF. combinations with bored-out nuts generally involved shearing of the bolt threads rather than of the nut threads, the bending and distortion of both nut and bolt threads being always very severe. These tests again show the poor resistance to repeated tightening of the UNF. combinations, compared with the other types. Boring out the nuts emphasised this difference in behaviour and, with such reduction of depth of engagement, there would appear to be no advantage, with respect to clamping load developed after only a few tightenings, in using UNF. in preference to B.S.F. or UNC. combinations.

Number of Turns of Nut

During the course of this investigation, numerous observations were made of the number of turns of the nut, relative to the bolt, required to develop various degrees of tightening, including tightening to yield and failure. This depends to some extent on the length of bolt and stiffness of the joint, but these factors are not as important as might at first appear, due to bolt elongation being concentrated in the threaded portion and to the relatively high stiffness of most load-bearing joints. There was, however, considerable variation in the observed values, and often a marked decrease, after the first tightening, in the amount of turning of the nut to produce a given tightening torque. This was no doubt due to flattening of high-spots on the bearing surfaces, thus changing the datum (hand-tight) position of the nut.

The following broad conclusions could be drawn. After a preliminary tightening and unscrewing to obtain a proper seating, half a turn of the nut from the hand-tight position would generally be sufficient to slightly exceed the yield for the B.S.W., B.S.F. and UNC. combinations in all three sizes. A few cases were encountered of B.S.F. combinations in the ¾in size, for which yield was not quite reached. The amount of turning for failure was always more than one turn, ranging up to one and two-thirds turns for ¾in diameter and up to two and a half turns for 1½in diameter. For B.S.W., B.S.F. and UNC. combinations, therefore, a preliminary tightening to a little below yield, followed by the application of half a turn of the nut from the hand-tight position, should develop satisfactory clamping under circumstances where more accurate methods of tightening are not available. The preliminary tightening would be especially important where the bearing surfaces were coated with rust or dirt.

For UNF. combination, on the other hand, such a method is not recommended as it is undesirable to tighten them to yield, which occurs due to thread bending. Half a turn of the nut would not exceed the yield for ¾in and 1½in UNF. combinations, although it might slightly exceed it for ¾in UNF. It could thus be taken as a safe value for UNF. in sizes above ¾in, if it was not required to develop maximum safe clamping load

in the larger sizes by more accurate means.

This method would not, of course, be suitable for joints incorporating soft gaskets or other flexible parts.

Conclusions

(1) The B.S.W. and UNC. combinations in all three sizes, and the B.S.F. combinations in the $\frac{3}{8}$in and $\frac{1}{2}$in sizes, generally failed by breakage across the core of the bolt, with pronounced necking. Many of the UNF. combinations in the smaller sizes, and all in the $1\frac{1}{2}$in size, failed by stripping of the nut threads, with severe bending of the bolt threads. The latter mode of failure occurs gradually, during a single tightening if sufficiently severe, and during a relatively small number of tightenings if yielding of the threads in bending occurs ; this might lead to serious over-tightening being applied and not detected on assembly, possibly with serious consequences when service loads were imposed.

(2) For a single pre-tightening, the clamping loads developed, as indicated by joint separating load, and the maximum tensile loads for failure, were not lower for the UNF. than for the other assemblies, for all degrees of tightening employed, in all three sizes.

(3) $\frac{1}{2}$–16 UNF. combinations satisfactorily withstood repeated assembly, if they were not tightened up to yield, which occurred at higher torques than for the other types. If these $\frac{1}{2}$–16 UNF. combinations were repeatedly tightened up to yield, progressive thread bending led to failure after a smaller number of tightenings than for the other types of combination ; under these conditions, the number of tightenings withstood increased with the pitch of the thread. Where tightening is controlled, as by proper use of a well-designed torque spanner, UNF combinations could be used to develop clamping loads about as high as for the other types of combination, even on repeated assembly, at least under laboratory conditions. The need for close control suggests, however, that the coarser threads would be more suitable for general service conditions.

(4) In the $\frac{3}{8}$in and $\frac{1}{4}$in sizes, the ratios of yield torque to failure torque for the four types of combination were in the following descending order of magnitude :—UNC., B.S.W., B.S.F., UNF. The ratio was also smallest for UNF. in the $1\frac{1}{2}$in size. For a given type of combination, the ratio decreased with increase of size, i.e. with increase of diameter/pitch ratio.

It is, therefore, not possible to specify a fixed " safe " percentage of failure torque for all types of combination, or even for different sizes of one type, without being unduly conservative in the case of coarse threads, having low diameter/pitch ratios.

(5) Taking the results of the main series of tightening and tensile tests for the three sizes as a whole, those for UNC. were the most consistent, the maximum variations from mean values never exceeding ± 7 per cent, except in a single case of pre-tightening to well above yield which would normally be avoided in practice. The results for UNF. and B.S.W. were the most inconsistent, those for UNF. particularly showing deviations up to 30 per cent below the mean value. The chances of encountering an abnormally weak combination thus appear to be greatest for UNF.

(6) Unified nut heights, for threads over 1in diameter, are calculated according to formulæ given in B.S. 1768 : 1951, Appendix C, page 28. The values so obtained are less than the corresponding values for Whitworth nuts, tabulated in B.S. 1083 : 1951, page 21, for threads up to 2in diameter. Since failure of the $1\frac{1}{2}$–12 UNF. combinations invariably occurred by stripping, it would appear desirable to increase the height (length of engagement) of Unified nuts, for threads over 1in diameter, to that of Whitworth nuts.

For similar reasons, it is suggested that, for UNF. in all sizes, and for B.S.F. in larger sizes (say over 1in), nuts for Code R bolts should be Code P and not Code A, as at present recommended in B.S. 1083 and 1768.

(7) Reduction of the depth of engagement to about 50 per cent of basic, by boring out the nut, reduced the resistance to repeated tightening, especially of UNF. combination. Clamping loads for a small number of tightenings were not seriously affected, except that the UNF. combinations were unable to withstand tightening torques as high as for normal UNF. combinations, and thus could not develop as high clamping loads. Use of an oversize tapping drill is thus to be discouraged for UNF. threads.

(8) As a rough guide under field conditions, for stiff metal-to-metal joints, the nut should be first well tightened (say to somewhat below yield of the combination), then unscrewed and re-tightened half a turn from the new finger-tight position.

(9) Hardness tests on the surface of the finished bolt are of little use for checking the quality of Code R bolts.

Recommendation

Where heavy loads have to be transmitted, it is advisable to avoid the use of UNF. threads unless tightening can be closely controlled, or unless their use is desirable for reasons other than those of strength. If such close control is possible, yielding of UNF. threads, which occurs mainly by bending, should be avoided. It should be borne in mind that loss of fit due to wear, corrosion and similar factors is especially serious in the case of fine threads.

The deficiency of UNF. threads implied in this suggestion is due not to the form of thread, but to the fineness of this particular series. UNF. was never intended as an automatic replacement for B.S.F. The coarse UNC. series should be adequate for most purposes.

Acknowledgments

The author acknowledges the assistance of Messrs. D. M. Waters and I. C. Craik, who carried out most of the experimental work. The work described above has been carried out as part of the research programme of the Mechanical Engineering Research Board. The article is published by permission of the Director of Mechanical Engineering Research.

APPENDIX :

Reasons for Different Modes of Failure

As stated under " Mode of failure," the B.S.W. and UNC. combinations in all three sizes, and the B.S.F. combinations in the $\frac{3}{8}$in and $\frac{1}{2}$in sizes, generally failed by breakage across the core of the bolt. Many of the UNF. combinations in the smaller sizes, and all in the $1\frac{1}{2}$in size, failed by stripping of the nut threads, with severe bending of the bolt threads. These differences may be qualitatively explained as follows.

Shear failure tends to occur at a diameter which is less than the major thread diameter by a small amount, proportional to the pitch, say at a diameter $D-ap$, where D=major diameter, p=pitch, a=constant (for a given form of thread ; there would not, in fact, be much difference between Unified and Whitworth threads). In other words, shear is assumed to occur at a distance below the major diameter equal to a given proportion of thread depth, which is itself proportional to pitch. The diameter of the cross-sectional area on which it is appropriate to base the tensile failure load (empirically found to be about the mean of the minor and effective diameters) is similarly equal to $D-bp$, where b=constant (b is greater than a). Now the tensile failure area is proportional to $(D-bp)^2$ and the shear failure area to $(D-ap)L$, where L is length of engagement, i.e. height of nut. The ratio T/S of tensile to shear failure load will therefore be proportional to :—

$$\frac{(D-bp)^2}{(D-ap)L} \text{ or to } \frac{(D-bp)^2}{(D-ap)D}$$

since nut height L is approximately proportional to nominal diameter D. Approximately, therefore,

$$\frac{T}{S} \propto 1-\frac{2bp}{D}+\frac{ap}{D} \propto 1-\frac{p}{D}(2b-a)$$

since $a < b < 1$ and $p \ll D$.

For a given nominal size D, the T/S ratio will increase as the pitch decreases, and shear failure will become more likely. Thus, the UNF. threads generally failed by stripping, whilst the coarser threads failed in tension across the core of the bolt.

Again, as size increases, the T/S ratio will increase as the p/D ratio decreases. This explains why the B.S.F. threads failed by stripping in the $1\frac{1}{2}$in size but not in the smaller sizes.

It must also be noted that the nut heights were not, in fact, constant for a given size of thread. The specification values and the L/D ratios are given in Table IX.

Table IX—*Specification Maximum Values of Nut Height, and L/D Ratios*

Size, in	Whitworth		Unified	
	Nut height, in.	Nut height / Nominal diameter	Nut height, in.	Nut height / Nominal diameter
$\frac{3}{8}$	0·312	0·83	0·33	0·88
$\frac{1}{2}$	0·687	0·92	0·66	0·88
$1\frac{1}{2}$	1·375	0·92	1·28*	0·85

* Calculated from formula given in B.S. 1768, Appendix C, page 28.

As required by the specifications, there was, for each size, a difference of a few per cent between the height of the B.S.W. and B.S.F. nuts on the one hand, and that of the UNC. and UNF. nuts on the other. The Whitworth nuts were thicker than the Unified in the $\frac{1}{4}$in and $1\frac{1}{2}$in sizes, but thinner than the Unified in the $\frac{3}{8}$in size. As the stripping strength of a combination is proportional to the nut height,[6] these differences probably explain the occasional stripping failures with $\frac{3}{8}$–20 B.S.F. combinations. They would also of course tend to increase the probability of stripping failure in the Unified combinations in the larger sizes. This is not important for UNC, but rather unfortunate in respect of UNF.

In the $1\frac{1}{2}$–8 B.S.F. case, all the combinations tightened to failure suffered breakage of the bolt, whilst those subjected to tensile load only failed by stripping of the threads. Similarly, there seemed to be a greater tendency to stripping failure in a pure tensile test for $\frac{3}{8}$–24 UNF. This may be due to the tightening failures occurring under conditions of combined tensile clamping load and frictional torque, though it is difficult to explain why other combinations did not behave similarly, e.g. $\frac{3}{4}$–16 UNF.

Yet another factor involved in the stripping strength of a combination is the reduction caused by increase of effective diameter clearance between the external and internal threads.[3] Any factors tending, in effect, to

increase this clearance will probably tend to do so by an amount independent of the fineness of the thread, e.g. standard bolt diametral tolerances are a greater proportion of thread depth for fine than for coarse threads ; again, wear, corrosion and decarburisation effects will tend to affect a certain depth of material which will be proportionately greater for fine than for coarse threads. Such factors might be important under some conditions of service. A further factor causing loss of diametral fit is the expansion of the nut under load. This varies from a maximum at the bearing end to practically zero at the free end. Measurements across the flats of $\frac{3}{4}$in and $1\frac{1}{2}$in nuts after test showed that the maximum nut expansion, expressed as a percentage of initial depth of engagement, was greatest for UNF. in both sizes, and averaged about 40 per cent. A similar result was obtained for those $1\frac{1}{2}$–8 B.S.F. nuts which had stripped, but in all other cases the values obtained averaged about 10 to 20 per cent.

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[6] Field, J. E., "Tensile Stripping Tests on B.S.W. $\frac{1}{4}$in —10 T.P.I. Threads," THE ENGINEER, 200, 5213, 1955, December 23, pages 901–902.

Ferromagnetic Coupling Development

Dry magnetic-particle clutches originating in the United States of America are now in use in Europe for industrial, automotive, and servo-mechanism applications. Excitation requirements are of the order of 1/1000 of the transmitted power, so that such couplings are particularly interesting in applications involving automatic control, separate servo-motors or amplifiers being often unnecessary.

A DRY magnetic-particle clutch designed to provide smooth torque control and power transmission, developed by Vickers Incorporated, is to be manufactured in this country by the Sperry Gyroscope Company, Ltd., Great West Road, Brentford, Middlesex. The torque transmitted by this equipment, which is known as the "Magneclutch," is controlled by the magnetising current and is independent of the shaft speed.

The main components of the clutch are a stationary frame, with a stator coil ; and two rotating members, the annular gap between them being partly filled by finely-divided magnetic metal powder. The cylindrical driving member is supported by a roller bearing in one end shield of the stator frame. The driving member, which is a hollow cylindrical rotor, partly encloses the driven member (and occupies the annular gap between it and the stator winding) and is carried in a roller bearing in the other end shield of the stator.

The driving and driven members can thus rotate at different speeds. Unless the stator is energised the finely divided ferromagnetic particles in the radial gap between the two rotors provide negligible frictional resistance and the torque transmission is practically zero. When the stator is energised the radial magnetic field in the gap magnetises the particles and torque is transmitted between the driving and driven members. The torque transmitted depends on the shear resistance between the chains of magnetic particles and its value can be controlled by varying the excitation current in the stator winding.

The main mechanical and electrical characteristics of the existing range of "Magneclutch" equipments are tabulated below :

"Magneclutch" type	Rated torque, ft lb	Drag torque (non-excited), ft lb	Max. speed, r.p.m.	Max. coil current, mA	Heat dissipation of outer member at 1,800 r.p.m., W
L6-2-2 ...	10	0·2	6,000	230	100
L6-2-3 ...	45	0·6	5,000	510	315
L6-2-4 ...	100	1·0	4,500	460	375
L6-2-6 ...	200	2·0	3,600	920	430

The "Magneclutch" demonstrated at the Instruments, Electronics and Automation Exhibition is illustrated in Fig. 1. This version is foot mounted, but flange mounting can be provided. Normally the stator is wound for 90V supply, direct current.

The dry particle clutches introduced to this country by S. Smith and Sons (England), Ltd., under the patents of the Eaton Manufacturing Company and the Dynamatic Corporation, have now completed a protracted period of development and are emerging into actual service.

The electrically-controlled clutch,* used with a synchromesh gearbox, is optional on production Peugeot and Panhard cars, the equipment being manufactured by the associated firm of Jaeger, in France, and production has now commenced of "Isetta" cars with the stationary-field air-gap clutch installation illustrated on page 628, November 1 last. This latter design not only has the advantage that the gap in the magnetic circuit reduces remanence considerably and therefore dispenses with the need to provide a small negative current when the clutch is required to be free, but also eliminates the use of sliprings and brushes : for these reasons the stationary-field design has superseded the slip-ring couplings of the original automatic transmission.†

* "Selectroshift" described on page 632, THE ENGINEER, November 1, 1957.

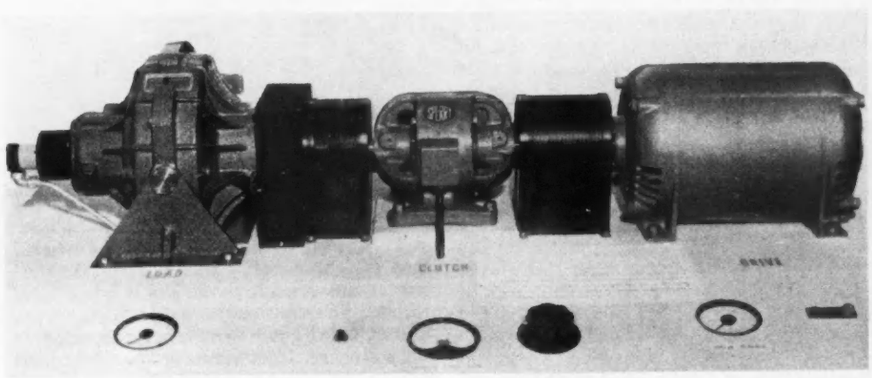


Fig. 1—Working demonstration of "Magneclutch" (magnetic dry-particle clutch) which is the central unit between the drive motor (right) and the load (left)

While a dog-clutch or sliding-gear gearbox requires particularly that the clutch free perfectly, a synchromesh gearbox demands a low inertia for the gearbox input members in order that an acceptable synchroniser life may be expected. A clutch designed and developed for the Porsche is illustrated in Fig. 2 : it will be seen that the principal components of the magnetic circuit are all on the driving member, and the driven member is merely a light cylinder carrying baffles to retain the magnetic particles. Although this member is obviously a far smaller heat sink, no distortion problems are encountered (the working air-gaps are about 0·025in deep). In order to minimise modification of an existing bell housing, sliprings are used with a rotating field coil. Now in the design stages is a corresponding fixed-field clutch, which will have six instead of four gaps in the magnetic circuit (the running gaps are about 0·010in) and which, to suit existing methods of assembling automobile components, will have the field coils mounted on the engine rather than on the clutch housing : this is rendered possible by ending the flywheel at the ring of bolts carrying the rear field piece, the front field piece being stationary. It will be noticed that these low-inertia clutches accommodate a much larger bearing for the front end of the main drive gear than

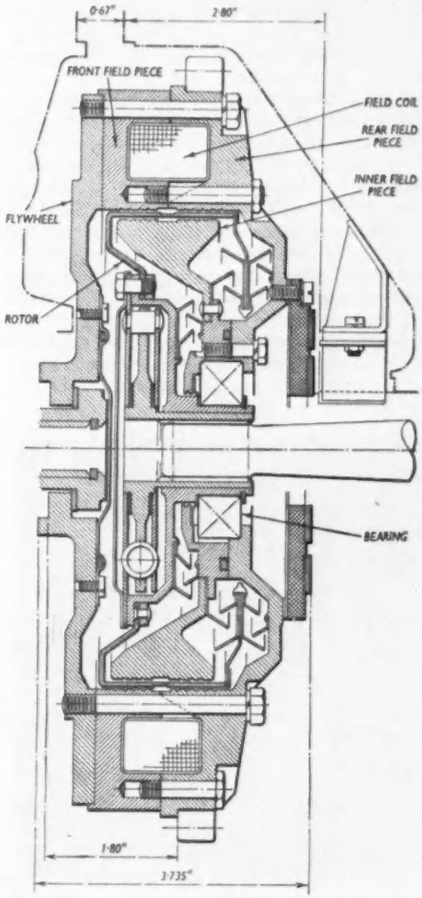


Fig. 2—Clutch of low output inertia for use with synchromesh gearbox

† "Autoselectric" transmission, described on page 587 THE ENGINEER, October 20, 1956.

is customary: this bearing is subject to conductive heating and adequate sealing is mandatory, since the presence of lubricant will obviously be prejudicial to the clutch. It will be clear that, when the output is brought to rest, centrifugal force will, in the case of the particles inside the driven member, no longer keep open the gap between driving and driven surfaces: there will therefore be a tendency for the output to run up to some speed of the order of tens of revolutions per minute above which the particles would remain clear of the inner, fast-moving, surface —this is, as mentioned above, tolerable to an all-synchromesh transmission such as that of the Porsche.

The fixed-field design is also used in a range of industrial couplings. Because of the rather small running clearances that must be maintained, the couplings are made completely self-contained, with both input and output located on a pair of ball bearings. These couplings are available in capacities of ¼, 1, 6, 12, 25, 50, 100 and 200 lb ft, but it is emphasised that the coupling is usually selected by the maximum power absorption required: the 50 lb ft version will dissipate 0·8 h.p. continuously. Operating voltages are 12, 24 or 180 d.c., or as requested: current consumptions are under the designer's control, reduction in demand being possible at the expense of increased copper and delayed response, but a typical excitation is 70W on the 50 lb ft unit, seen below.

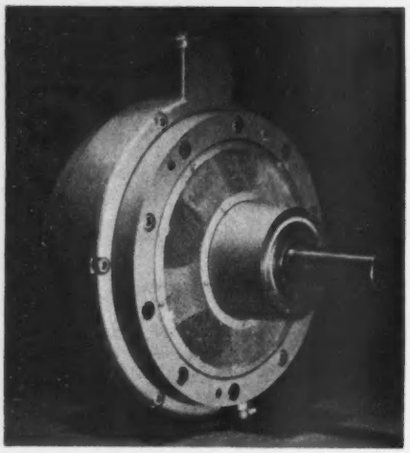


Fig. 3—Magnetic-particle coupling for industrial drives with an output member 5¼in. diameter and a torque capacity of 50 lb ft

It may be worth while to recall some of the general characteristics of this class of coupling. Since the working medium is, when the clutch is slipping, raised to a very high temperature in a strong magnetic field, it is essential that it be highly resistant to permanent magnetisation: this is found to be satisfied if the carbon content is less than 0·08 per cent. The dry particles are also subject to oxidation at their working temperatures, and for this reason a high chromium alloy is specified: the gradual impairment of performance with service is attributed to this phenomenon, allied with pitting of the friction surfaces. The effect of short-term overloading is to cause over-temperature of the field windings, leading to insulation failure and reduction in the effective number of turns. It can be seen that both modes of failure tend to increase the heat input to the clutch and deterioration therefore tends to accelerate: there is at present no way of designing a "fail safe" coupling.

Mechanical Handling Exhibition

No. I

THE Mechanical Handling Exhibition and Materials Handling Convention opened in London at Earls Court on Wednesday, May 7, and will be open daily until Saturday, May 17. This year more than 250 firms are showing representative examples or models of their products, and for the first time some manufacturers from overseas are participating in the exhibition. As in previous years, practically every form of mechanical handling and conveying device is represented, and at the convention running concurrently with the exhibition, papers are being presented dealing with the latest handling methods in particular industries.

Mechanical handling has become an important factor in promoting economy in manpower and combining efficiency with speed in all branches of industry and commerce where loads, great or small, have to be moved or manipulated. This fact has only been generally appreciated by the smaller industrial concerns in this country in relatively recent years, for it was long considered by many that the full advantages of mechanical handling were only obtainable at fairly high capital cost in large establishments. Possibly this was, and is, correct in certain circumstances, but more recently there has become available a steadily increasing amount of time and labour-saving handling equipment suited to the smaller user. This is borne out at the exhibition, where small hoists, conveyors, power trucks, platforms and other items of equipment calling for a reasonably small capital investment are shown on a number of stands.

The larger industrial establishment concerned with the handling of big and heavy loads will be interested in the steadily increasing capacity of the heavy duty mobile and static lifting and conveying equipment now available as standard rather than as specially designed products. Again, many kinds of awkward and fragile loads, hitherto calling for manual or manually-assisted manipulation on the factory floor, and in warehouse or stockyard, are now within the scope of mechanical plant. It would appear to be difficult indeed for a visitor to the exhibition to present a handling problem which not one but several of the firms represented could offer a solution on the basis of actual experience.

It is, however, not in the unusual handling problem that the main interest of the exhibition lies—it is in its presentation of a wide selection of standard equipment adaptable for every day handling of goods of all kinds. With the variety of equipment now made it is not easy for a prospective user to select that which will best suit his purpose without seeing the full range available. In presenting under one roof a comprehensive range of products the exhibition provides a valuable opportunity for comparing the different machines and methods and discussing their advantages with specialists in handling problems.

Many of the new machines and plant of new design in the exhibition have already been described in our columns. This does not, however, imply that there is any lack of new or improved plant to be seen, but in the main development seems to have been more concerned with detail improvements and extensions to existing ranges of known and tried equipment. For this article on the exhibition we have selected some of the machines and equipment which have not been described before and which incorporate points of interest.

As in previous years, a comprehensive range of cranes of all kinds is being shown, and in general it might be said that only design developments in detail and extensions to existing designs have been made in many cases. Many interesting mobile cranes provide spectacular exhibits and it will be noted how the range and capacity of these machines is steadily extending. A particularly noticeable amount of attention continues to be paid to reducing driver fatigue on cranes by fitting them with light air-hydraulic or electrically-actuated controls for the motions.

An example of a recently introduced design of light, simple motion selection by switches is to be seen on the "Coles" cranes (described in our issue of April 25). In these cranes a small switch console installed in the driver's cab gives finger selection of motions, and the speed of the selected motion is controlled by the engine accelerator pedal. This simple form of switch lever control enables a man to maintain full control of a motion without physical effort and concentrates his full attention on the load itself. It speeds working and gives a greater degree of safety when controlling cranes under the difficult conditions in which mobile cranes often have to operate.

A new truck-mounted crane of Thomas Smith and Sons (Rodley), Ltd., which is illustrated in Fig. 1, is built for a maximum

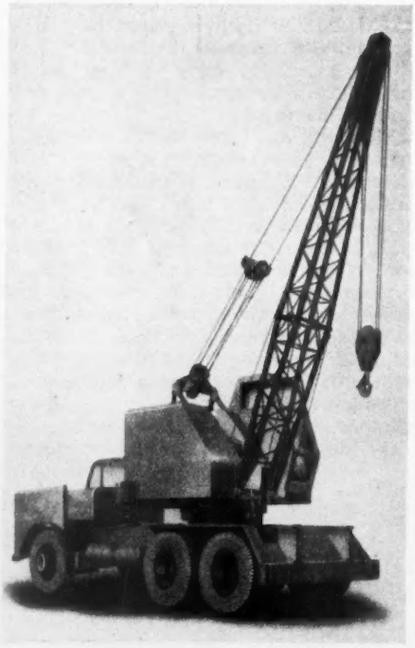


Fig. 1—8-ton truck-mounted crane—T. Smith and Sons (Rodley), Ltd.

load of 8 tons at 9ft radius when the outriggers are extended. It has a completely revolving superstructure and is fitted with a four-cylinder Ford diesel engine developing 40 b.h.p. at 1600 r.p.m. The basic 25ft centres jib can be extended to 65ft with intermediate sections and, if required, a ½ cubic yard digging attachment can be

fitted. The truck is a Ford chassis converted by All Wheel Drive, Ltd. to either a 6 by 6 or a 4 by 4 drive, and it is powered with a six-cylinder diesel engine developing 100 b.h.p. at 2500 r.p.m. Drive is transmitted through a four-speed gearbox to an independent propeller shaft to each axle.

The fast mobile crane shown by Ransomes and Rapier, Ltd., of Ipswich, can be driven at normal road speeds and is specially intended to meet road travelling requirements of inter-depot service on railways and similar undertakings. It has a lifting capacity of 8000 lb at 4ft outreach to a height of 14ft or 3600 lb at 10ft outreach to a height of 6ft, jib extensions being available to increase the working radius of the crane.

On the stand of George Cohen, Sons and Co., Ltd., there is a Jones "KL 10–10" mobile crane fitted with a 90ft jib and a 15ft jury mast. This design of crane was described in our issue of May 24, 1957; it is built to travel on the road at speeds of up to 30 m.p.h. The "KL 10–6" design of crane is now available in a rail-mounted version and it is shown on a shunting chassis fitted with a 30ft jib and 40in electro-magnet. A second "KL 10–6" is shown mounted on pneumatic-tyred restrictor wheels, with power-assisted steering, whilst a third model is mounted on an A.E.C.-A.W.D. heavy-duty crane carrier chassis.

Fork Trucks

Some sixteen models of diesel-engine and electrically-driven fork trucks shown by Conveyancer Fork Trucks, Ltd., Warrington, include a new design of 2-ton truck for yard use, which is fitted with a torque converter. A new reach truck made by this firm is for operating in narrow gangways and carries the load within its own wheelbase. The electrically-propelled model shown has a capacity of 2000 lb at 24in load centres and a 3000 lb version of the machine is also being made. Machines are being demonstrated with various attachments for handling drums, bricks, reels and pallets.

A fork truck with a slewing mast, on the stand of Ransomes and Rapier, Ltd., was described in our issue of January 21, 1955. This machine is of the same general design as an orthodox fork truck, but its mast is arranged to swivel on one side to enable a load to be carried in line with the direction of travel. The truck picks up a load in a similar way to a fork truck and, with a combined steering and slewing manœuvre, withdraws it from a line of sets so that it finishes with the load alongside to present a minimum width for travelling and a minimum effective length for manœuvring. The slewing mast has the advantage that it enables the truck to enter a transverse lane between sets in a stockyard, pick up a load at the end, back out with it into the main gangway and manœuvre into its travelling position with the load alongside.

The machine has a road speed up to 20 m.p.h. and its lifting and carrying capacity of 12,000 lb at 24in from the face of the forks is large enough to load a lorry from one side.

The "Irion" side operating fork lift carriers of German manufacture have been marketed in this country by Materials Handling Equipment (Great Britain), Ltd., 40A, Dover Street, London, W.1, for some years, and it is of interest to note that these machines are now to be made under licence in Britain. The British-built machines will be of the same general design as the German machines and will be powered by a Ford 61·5 b.h.p. diesel engine and transmission. The "Irion" machines at Earls Court include one of 11,000 lb capacity and a battery-operated model of 20/30 cwt capacity. These side-loading trucks have forks which can be traversed laterally to pick up and deposit loads, and they can be driven forwards and backwards in gangways down to 6ft wide with equal facility.

The new "NR40" battery fork lift truck of Ransomes, Sims and Jefferies, Ltd., Ipswich (Fig. 2), has a capacity of 4000 lb at 24in load centre or 2 tons at 20in. A new design of mast has been introduced to improve the operator's view and slightly reduce the collapsed height. A dual-speed motor now fitted gives alternative travelling speeds of

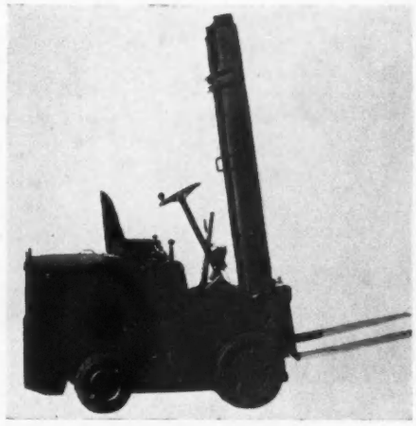


Fig. 2—Electric fork truck with dual speed motor. It has a capacity of 4000 lb at 24in load centres or 2 tons at 20in—Ransomes, Sims and Jefferies

5·5 or 4·5 m.p.h., and is stated to give a useful power saving as well as enabling a speed ratio to be selected in accordance with floor conditions.

A new series of fork lift trucks of 2000 lb to 4000 lb capacity introduced by Coventry Climax Engines, Ltd., Coventry, is available with electric, diesel, petrol or L.P.G. engine drive. These "Universal" trucks, one of which is illustrated in Fig. 4, incorporate a large number of interchangeable parts, such as the drive axle, steering axle, mast assembly and hydraulic equipment. In them the three-point wheel arrangement of the makers other trucks has been replaced by a four-wheel layout using a longer wheel base. The

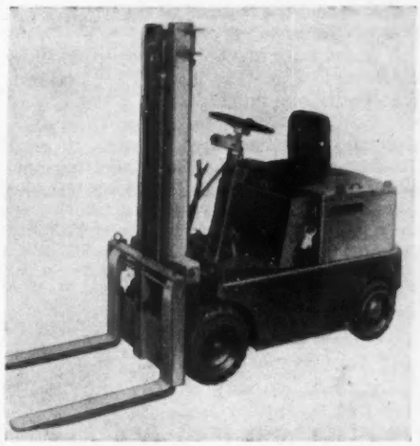


Fig. 4—"Universal" electric fork lift truck, also available with diesel, petrol or L.P.G. engine drive, and for capacities of 2000 lb, 3000 lb and 4000 lb—Coventry Climax

engine-driven machines can be supplied with either a clutch and constant-mesh gear drive, or a Brockhouse torque converter drive. Automobile hydraulic brakes are fitted on the engine-driven machines, whilst the battery machines have hydraulic brakes on the front wheels with dynamic braking and drum transmission brake.

Amongst the loading machines shown there is the new machine of Mathew Brothers, Ltd., of Wallington, Surrey, which is illustrated in Fig. 3. This four-wheel drive, four-wheel steering machine, with a bucket of 1¼/1½ cubic yards or 4000 lb capacity, is driven by a 61 h.p. Ford diesel engine. The bucket has a maximum lift height of 120in under the hinge, with an outreach of 38in from bucket tip at 84in height to 22in from bucket tip at 98in height. Power is transmitted through a torque converter and a gearbox to the two double-reduction driving axles, giving four road speeds up to 16 m.p.h. forward and two up to 8 m.p.h. in reverse.

The centre point articulated steering is hydraulic power assisted and the bucket mechanism is hydraulically operated through grouped controls round the steering wheel. The 14in by 24in earth mover tyres are interchangeable and with the four-wheel steering the machine has an outside turning radius of 13ft. Its gross working weight is

Fig. 3—Four-wheel drive, four-wheel steering loading shovel—Mathew Brothers

15,000 lb and the theoretical tractive force in bottom gear at stall is 16,800 lb.

A heavy-duty loader now being made by E. Boydell and Co., Ltd., Old Trafford, Manchester, is fitted with a $\frac{7}{8}$ cubic yard full width bucket. It is a four-wheel drive machine with steering effected through clutches and brakes working on opposite sides, as with a tracked vehicle. Twelve forward and four reverse speeds are available. One of the two dumpers shown by C. H. Johnson (Machinery), Ltd., Stockport, Cheshire, is the "Twin 65," which has a rated capacity of 65 cwt, permitting a payload of 45 cwt. It is driven by a 12 b.h.p. air-cooled Petter diesel engine and fitted with orthodox heavy-duty vehicle transmission, giving three forward speeds of up to 12 m.p.h. and reverse.

A new front wheel drive hydraulically-operated overloader introduced by the Merton Engineering Company, Ltd., Faggs Road, Feltham, Middlesex, is shown in Fig. 5. This machine has been designed for variable discharge heights at both the front and the rear, the arms being actuated by two pairs of hydraulic rams only. It is driven by a Ford diesel engine developing 60 h.p. and through a Brockhouse torque converter transmission which has a 3 to 1 stall ratio. A full power shift epicycle gear train gives two forward and one reverse speed, and power assisted steering is provided for the rear wheels.

Fig. 5—1 cubic yard bucket overloader with variable discharge heights at front and rear—Merton Engineering

The machine is fitted with a standard 1 cubic yard capacity bucket and can be provided with a bulldozer blade, crane hook or fork lift attachments. A second model of the same design is fitted with a gearbox transmission giving six forward and two reverse speeds.

Conveyors and Elevators

The vast increase which has taken place in the mechanical handling of goods and materials in all forms to reduce labour requirements and speed work in industrial and commercial establishments has resulted in the development of a vast selection of conveyors and elevators for general and special applications. The selection of conveyors now available is shown to good effect on a number of stands. In many cases they have been arranged in closed circuits with elevators and automatic control gear to show the way in which they can be adapted for different classes of handling and to suit particular flow patterns. Typical of such installations is that by Thos. W. Ward, Ltd., Sheffield, in which there is an automatic digital control system for routing incoming goods into a stores with automatic selection made through a control panel of goods required from stores into production. The system incorporates unit belt conveyors, gravity roller conveyors, disc roller runways and a unit overhead chain conveyor.

An overhead chain conveyor system, known as the "Flowlink," which is made by Fisher and Ludlow, Ltd., Birmingham, 12, is designed particularly for handling bulky loads carried in mobile trucks. These trucks run on the floor and are towed round a closed circuit by ball pendant chains suspended from the overhead chain system. The trucks are fitted with safety buffers and release trip resetting handles for operation at the loading and unloading stations.

A scale model on the stand of the New Conveyor Company, Ltd., Smethwick, Birmingham, is used to demonstrate the "Wissman" swarf and chip conveyor the company is now making under licence. These conveyors, one of which can be seen in Fig. 6, are designed to handle bushy as well as broken swarf, together or separately, and also cast iron swarf, in either a dry state or associated with cutting or cooling liquids, from lines of automatic machines. The conveying medium is a steel tube open on the underside, and built up in standard lengths coupled together. The tubes are fitted at regular intervals with tapered fins shaped to push the material during the forward stroke and to pull through it on the return stroke.

The flat plate base of the conveyor is attached to the floor of a concrete trench or to a mild steel trough, and fitted with a vertical plate support to which are attached bearing bushes in contact with the inner surface of the conveying tube. This conveying tube is oscillated slowly by a hydraulic cylinder having a stroke of 5ft. The necessary hydraulic power is supplied by a motor-driven pump under the control of a time switch which provides intermittent operation. The timer is so designed that one pump unit only is necessary on a multi-conveyor installation as not more than one cylinder is in operation at any given time.

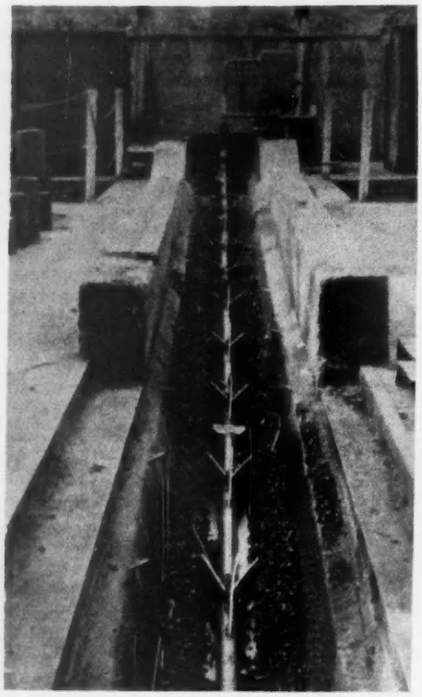


Fig. 6—Swarf and chip conveyor in which a finned conveyor tube is oscillated over a stroke of 5ft—New Conveyor Company, Ltd.

A standard power unit to convert gravity roller conveyors into power driven belt conveyors is shown by George Cohen, Sons and Co., Ltd. It has a $\frac{3}{4}$ h.p. geared electric motor which provides a standard belt speed of 25ft per minute, although faster speeds are available. Fitting of the units is simple; the terminal units and tracking unit bolt directly on to existing spindle holes, and the return belt troughs clip into the existing side frame angles—no drilling is required. The driving and tensioning assemblies require only four holes, which are drilled into the side frame angles of the conveyor.

(*To be continued*)

550MW Turbo-Generator Set

As announced recently, the Central Electricity Generating Board is placing an order with C. A. Parsons and Co., Ltd., Heaton Works, Newcastle upon Tyne, 6, for a 550MW turbo-generator which will be the first of its kind and the largest in the world.

It is interesting to recall the rapid increase in the size (or, more correctly, the capacity) of turbo-generator sets in this country in the past twelve years. To obtain the maximum output of plant in an era of acute shortage the immediate post-war programmes were concentrated on standard sets of 30MW and 60MW output. Later the Central Electricity Authority placed orders for units of 100MW output to operate with steam conditions of 1500 lb per square inch pressure, 1050 deg. Fah. temperature and others of the same rating but with steam conditions of 1500 lb per square inch, 975 deg. Fah., with reheating to 950 deg. Fah. These machines were followed by others of 120MW output with steam conditions of 1500 lb per square inch, 1000 deg. Fah., and reheating to 1000 deg. Fah. Such a machine is shown in Fig. 1 under construction at Heaton Works for Kincardine power station.

By 1956 Parsons had received orders for machines of 200MW output for installation in generating stations in England and Canada. The machines for England were ordered by the C.E.A. for installation in West Thurrock generating station; they will be single-line units driving a single hydrogen- and liquid-cooled generator. The machines for Canada were ordered by the Hydro Electric Power Commission of Ontario, for the extensions to the Richard L. Hearn generating station, Toronto, where Parsons had previously installed four 100MW hydrogen-cooled sets between the years 1951–53. The addition of four 200MW machines will bring the installed capacity of the station to 1,200,000kW.

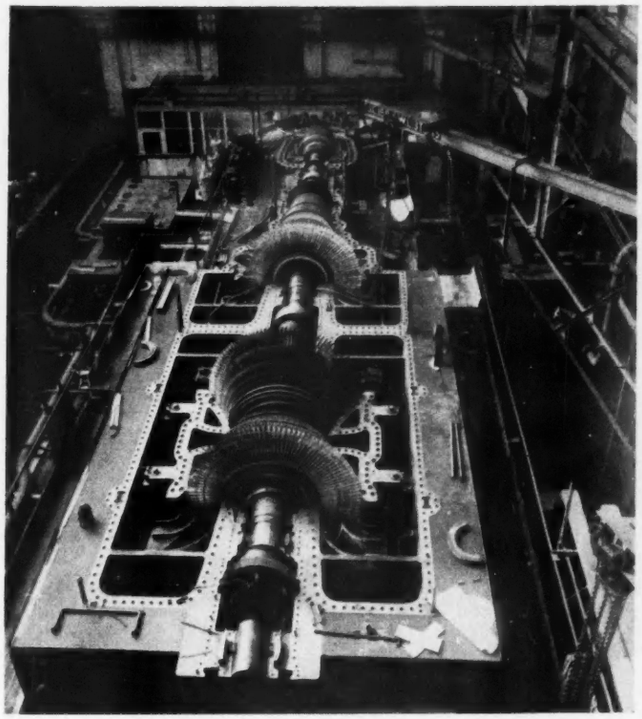


Fig. 1—120MW turbine under construction at Heaton Works for Kincardine power station. The steam conditions are 1500 lb per square inch at 1000 deg. Fah. reheating to the same temperature

These 200MW machines are of cross-compound design with the high-pressure lines of the turbines running at 3600 r.p.m. and the low-pressure lines running at 1800 r.p.m., each line being coupled to a 100MW hydrogen-cooled generator. The i.p.-l.p. line is shown (Fig. 2) erected at Heaton Works.

The turbines of the single line 200MW units are four-cylinder machines comprising an h.p. i.p. and two double-flow l.p. cylinders, the steam conditions at the stop valve being 2350 lb per square inch pressure, 1050 deg. Fah. temperature, with reheating to 1000 deg. Fah. The steam conditions for the cross-compound turbines are 1800 lb per square inch pressure, 1000 deg. Fah. temperature, with reheating to 1000 deg. Fah.

Last year orders were received for two machines of 300MW output for a new generating station at Lakeview, near Toronto, Canada. The turbines for these machines will be of cross-compound design, taking steam at 2350 lb per square inch pressure, 1000 deg. Fah. temperature, with reheating to 1000 deg. Fah.

In the design of the generators for the 200MW machines under construction for the C.E.A., the limitation in size for transportation becomes a major problem. Parsons therefore decided on water cooling of the stator windings to allow a greater output to be obtained from the generator, for the same frame size and temperature rise. Permission was given by the C.E.A. to make a prototype winding for a 60MW hydrogen-cooled generator which was to be installed in Tilbury generating station. This generator was commissioned in the early part of this year. The new cooling system permits generators over 300MW to be made within the transport limits.

Such developments have made possible, to-day, the 550MW Parsons turbo-generator. This turbo-generator will be a cross-compound unit consisting of two lines arranged in tandem, each line comprising four turbines driving a 275MW hydrogen- and liquid-cooled generator. A photograph of a model of the complete machine is reproduced in Fig. 3. All eight turbines are double-flow machines with the high-pressure cylinder on the first line. From the exhaust of this cylinder the steam is reheated and passed to the first intermediate-pressure cylinder on the second line.

On leaving this cylinder the steam divides equally between duplicate second intermediate-pressure cylinders, one on each line. Final expansion of the steam is then through two low-pressure cylinders on each line. A single-row velocity wheel is used in the initial stage of both the high-pressure turbine and the first intermediate-pressure turbine, and reaction blading is used throughout the remaining rows. Both the high-pressure cylinder and the first intermediate-pressure cylinder are of double-shell construction.

The machine will operate with steam at an initial pressure at the stop valves of 2300 lb per square inch and a temperature of 1050 deg. Fah. Reheating is to 1050 deg. Fah. Steam is led to the turbine through two steam chests arranged one on each side of the high-pressure cylinder. Each chest is of forged construction, containing two runaway stop valves and two governor valves. Because of the large storage capacity of the reheat system, it is necessary to prevent steam flowing into the turbine when sudden loss of load occurs. Therefore, intercept and reheat emergency stop valves are incorporated in the reheat system; release valves, which simultaneously release this steam to the atmosphere, act as an additional safeguard.

The turbines will have two governors; the main speed control governor is driven from the high-pressure turbine shaft and an auxiliary governor is driven from the first intermediate-pressure turbine shaft. One governor is provided on each line of turbines and is mounted on a cross shaft driven through a worm and wheel.

Arrangements are made to extract steam from the turbine at seven pressure points to heat the condensate returning to the boiler, to a temperature of 486 deg. Fah.

To ensure uniform heating and cooling of the four turbine spindles and generator rotor on each line, when starting up or shutting down the machine, motor-driven rolling gears are to be provided. With these gears the machine can be kept slowly turning after being shut down, so that distortion due to unequal temperature distribution is avoided. Steam from the eight exhausts is to be dealt with by four condensers with a total cooling surface of 330,000 square feet.

The generators will operate at 18kV, 0·85 p.f., 50 c/s, at the design speed of 3000 r.p.m. The rotors are to be direct-gas-cooled, operating in hydrogen at a pressure of 45 lb per square inch. Each stator will have a direct-cooled winding, using demineralised water as the cooling medium circulating through the conductors, which will be built up of hollow rectangular copper tubes.

Excitation for each generator is to be provided by a main and pilot exciter driven from the generator rotor shaft through reduction gearing. Ventilation of the exciters is by the circulation of air round a closed circuit by a blower mounted on the pinion of the gear drive to the main exciter shaft.

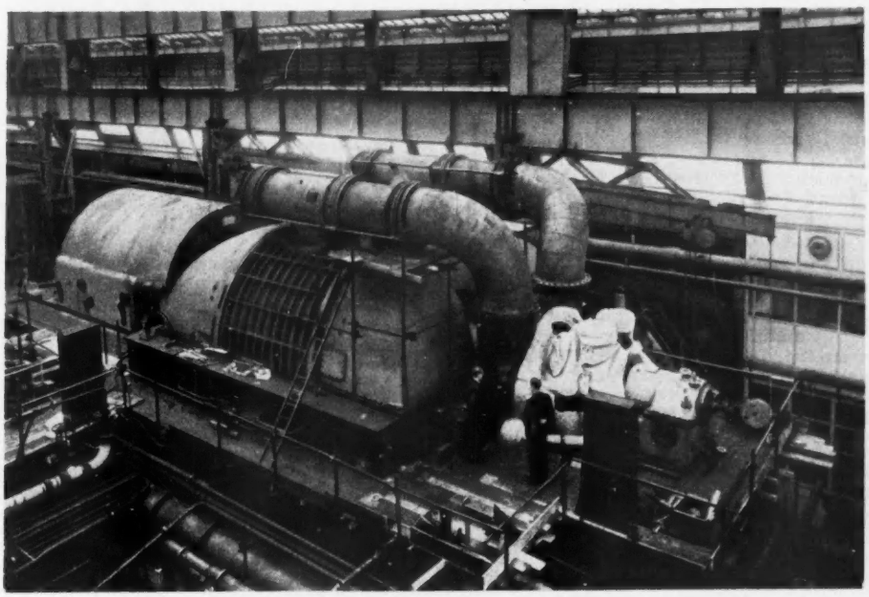


Fig. 2—l.p.-l.p. of 200MW cross-compound set erected at Heaton Works. It is one of four sets for the Richard L. Hearn power station, Toronto

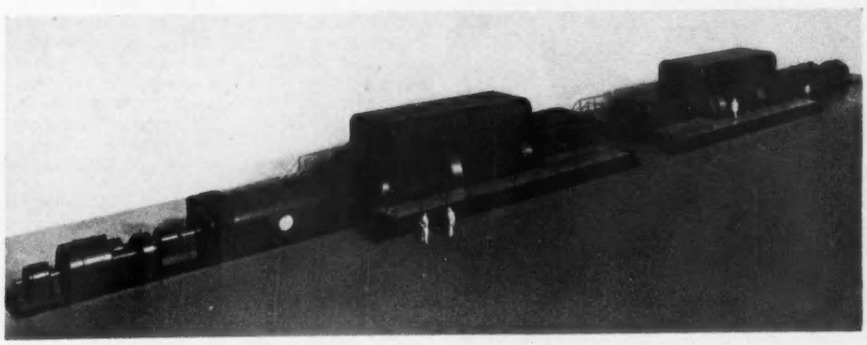


Fig. 3—Model of 550MW cross-compound turbo-generator, consisting of two lines in tandem, for the Central Electricity Generating Board

SHORTER REPORTS

Defence Projects

THE first flight has now taken place of the Blackburn and General Aircraft Company, Ltd., "N.A.39" naval strike aircraft. The machine is powered by two de Havilland "Gyron Junior" engines which provide a portion of the compressor delivery for blown flaps or other high-lift devices, presumably to meet the needs of a highly controlled, low-speed approach to a carrier deck; flight trials of the engine fitted with reheat are to be commenced later this year on a Gloster "Javelin," suggesting that reheat is not a feature of the "N.A.39"—this is consistent with the demand for fuel economy on naval machines, which, in any case, employ assisted take-off. The engine installation is, it will be seen in the accompanying illustration, reminiscent of that of the "Javelin," while the airframe as a whole resembles a Handley Page "Victor"; the one major departure, the extreme area-rule "bulge" above the wing root trailing edge, confirms that the performance is transonic. There is a large stores bay under the fuselage, and a further detachable panel behind that. It is also apparent that the engines are mounted close up to the intakes, rather in the manner of an Avro "C.F.-100," thus making room for the undercarriage.

The remarkable feature of the design is the very great length. The "Scimitar" uses a hinged nose to allow it to pass down carrier lifts, illustrating that span is by no means the only critical dimension, but the "N.A.39" seems to feel no restriction in this direction; it will be noticed that the crew are in tandem, and the dive brake assembly projects far behind the tail.

It has been announced that the British intermediate-range ballistic missile is being built by de Havilland Propellers, Ltd., as prime contractors, with Rolls-Royce, Ltd., de Havilland Aircraft Company, Ltd., and the Sperry Gyroscope Company, Ltd., as main contractors. The parent firm of Sperry are responsible for the "Sergeant" tactical bombardment missile and are associated with guidance systems employing air-bearing gyroscopes for the "Redstone" and "Jupiter" missiles of the U.S. Army Ballistic Missile Agency. Rolls-Royce hold licences from North American Aviation to build pivoted-chamber motors such as the Rocketdyne units of around 70 tons thrust used on the "Jupiter" and the Douglas "Thor," and as boosters on the Convair "Atlas." So far as is known, this is the only I.R.B.M. in a similar stage of development to use a liquid-propellant engine. It is reported to differ from all present and projected I.R.B.M. in that it may be fired "with extreme accuracy over a range of several thousand miles."

Aero Engine Sponsorship

To co-ordinate the resources and activities of Bristol Aero-Engines, Ltd., and Armstrong Siddeley Motors, Ltd., the Bristol Aeroplane Company, Ltd., and the Hawker-Siddeley Group, Ltd., have formed a new company, Bristol-Siddeley Engines, Ltd., owned equally between them. While existing commitments will continue to be discharged by the two engine manufacturers, new contracts and development of new engines will, we understand, be handled by the new company, which may divide the work between the two firms. The chairman of the new company is Sir Arnold Hall, and the vice-chairman Air Commodore F. R. Banks. Technical co-operation between the existing firms has already started.

It is pointed out that the existing products of the two firms are entirely complementary. Turbo-jets include the large two-spool Bristol "Olympus" of up to 10,000 lb thrust, the large single-spool A.S. "Sapphire," of 11,000 lb thrust, the Bristol "Orpheus," of 6810 lb and the A.S. "Viper," of 2460 lb. The turbo-prop engines comprise the free-turbine "Proteus" and the fixed-shaft "Python" of 4120 e.h.p., the "Double Mamba" of 3850 e.h.p., the "Mamba" of 1775 e.h.p., and the new "P.182," of 1180 e.h.p. Bristol have one piston engine, the "Centaurus," the "Marine Proteus," and ram-jets, such as the "Thor," while Armstrong Siddeley are developing a helicopter turbine, the "P.181," of 1100 h.p., and a hydrogen peroxide rocket engine. Absent from the range are high performance rockets, Armstrong Siddeley having abandoned liquid oxygen as an oxidant, and solid fuel rockets being handled by Bristol Aircraft, Ltd. We understand that the new company will have access to the research into nuclear power done by the Hawker Siddeley Group.

275kV Crossings of the Severn and Wye

WORK has been started on the construction of the Central Electricity Generating Board's 275kV overhead-line crossing of the rivers Severn and Wye near Aust. This crossing project is the largest to be constructed in the United Kingdom and will carry two 275kV circuits between Melksham in Wiltshire and Uskmouth in Monmouth. The incoming transmission lines at each end of the crossing are to one of the Board's standard 275kV designs having twin 0·175 square inch copper equivalent s.c.a. conductors per phase, with a nominal capacity of 375MW per circuit. The Severn and Wye crossing comprises three spans and four towers, that is two high crossing towers and two anchor towers, the total length of the three spans being 4000 yards. The crossing is about 330 yards downstream of the proposed Severn suspension bridge and is adjacent to the route of the Aust–Beachley Ferry. To ensure that the crossing should have a close measure of alignment with the future bridge, the high crossing tower on the Aust side of the river is to be built on an artificial island about 300 yards from the base of Aust Cliff. The other crossing tower will be built on the southern tip of the Beachley Peninsula.

A summary of the main dimensions of the towers, conductors and insulation is tabulated below.

Main Particulars of Severn and Wye Crossing

Total length of crossing	12,000ft
Main crossing span (over the River Severn)	5310ft
Aust anchor span	2830ft
Beachley anchor span (over the River Wye)	3860ft
Overall tower heights (above base):	
Aust crossing tower	488ft
Beachley crossing tower	471ft
Main span maximum sag	265ft
Minimum clearance to River Severn at mean high water, Spring tides	135ft
Conductors (S.C.A. construction):	
Overall diameter	1·695in
Stranding	Steel—91×0·113in Aluminium— 78×0·113in
Calculated ultimate strength	227,000 lb
Insulators (make-up of sets):	
Suspension sets	4 strings each consisting of 18, 12,000 lb units (anti-fog)
Tension sets	8 strings each consisting of 18, 12,000 lb units (plain shed)

For this project a special steel-cored aluminium conductor, stated to have a higher ultimate strength than any conductor yet manufactured anywhere in the world, will be used. Because of the size of the conductor, only one per phase will be necessary for 275kV working: the conductor for each phase will be manufactured in one length, with no joints, and will be anchored at each end by means of compression-type tension clamps. In view of the weight of conductor to be handled during stringing operations, special techniques are now being developed, but the details have yet to be finalised.

Each high crossing tower suspension insulator set will consist of four, 275kV strings of toughened glass anti-fog units in parallel, with suitable balancer linkages at each end of each string. At the anchor towers, each conductor will terminate on a tension insulator set which will consist of eight, 275kV strings of toughened glass, plain shed units in parallel also incorporating suitable balancer linkages. The single earth-wire will be of the same construction as the line conductors and arranged to give a 45 deg. shielding angle. All seven conductors will be grease-impregnated, fitted with Stockbridge vibration dampers, and protected by aluminium-alloy armour rods where they are supported in the suspension saddles.

The "island" to support the Aust side high crossing tower consists of a reinforced concrete platform supported by five piers. The piers are formed from pre-cast rings, filled with mass concrete, and seated on box piles. The access gantry to the "island" is constructed from pre-cast trestle units connected by pre-cast decking. The footings for the high crossing tower are founded in the rock on the Beachley Peninsula and the two anchor towers will have mass-concrete block foundations.

Generally, the towers are constructed of single or compound rolled-steel angle sections, except that the bottom panels of the high towers will consist of box-type girders, each formed from four angle sections suitably laced together. In all towers there will be a high proportion of high-tensile steel.

It is intended that the Severn–Wye crossing should be completed and in commission by the autumn of this year.

The "NA 39" has a marked resemblance to earlier British aircraft, but the whole of the tailplane is movable

Anglo-Italian Collaboration in Nuclear Power

A FORMAL agreement for long-term collaboration between AGIP Nucleare,* of Milan, and the Nuclear Power Plant Company, Ltd., of Knutsford, Cheshire, was signed in London last week, by Signor E. Mattei, president of AGIP Nucleare, and Sir Claude D. Gibb, chairman of the N.P.P.C. This agreement provides for collaboration in the construction of nuclear power stations in Italy over a minimum period of seven years. It covers the exchange of information on the design, construction and operation of nuclear power stations, the training of technical staff and collaboration in research. It also paves the way for a second agreement (due to be completed shortly) which will provide for the construction of a nuclear power station with a single graphite-moderated, gas-cooled reactor and a guaranteed output of 200MW. This station will be built on a site near Latina, about 40 miles south of Rome ; work is expected to begin before July 1 this year, and to be completed in 1962. The customer for the power station will be the Società Italiana Meridionale per l'Energia Atomica (SIMEA), an organisation owned jointly by AGIP Nucleare and the Instituto per la Ricostruzione Industriale (IRI). AGIP Nucleare will undertake the civil engineering and building work in close co-operation with the Nuclear Power Plant Company and will also be responsible for the correct manufacture and testing of all components to be made in Italy. The British company will be responsible for the overall design of the station and for its satisfactory commissioning, and will supply the major components, including the reactor itself with its ancillary equipment, the boiler heat transfer elements and the turbines.

The overall design of the 200MW station has been provided by N.P.P.C., but the detailed design will proceed in collaboration with AGIP staff, who will adapt it to suit local requirements as well as Italian practice and standards. Engineers from AGIP Nucleare and N.P.P.C. are already at work in the offices of their opposite numbers. Early in February, AGIP Nucleare set up a laboratory for applied research, which, it is hoped, will be to the mutual advantage of both parties to the agreement recently signed.

* AGIP Nucleare, which was formed in 1957, is one of the five main concerns which go to make up the Italian state-controlled organisation Ente Nazionale Idrocarburi (ENI), with its headquarters at San Donato Milanese, near Milan.

Tropospheric-Scatter Radio Link

EXPERIMENTAL work on tropospheric-scatter has been in progress for a number of years by Marconi's Wireless Telegraph Company, Ltd., Chelmsford, Essex, and since 1956 the company has had in use an experimental system between Bromley in Essex and Catterick in Yorkshire.* This experimental system has been used mainly for analysis of the transmission characteristics and to provide data for systems planning.

Side-by-side with this work a range of tropospheric-scatter transmitting and receiving equipment has been designed and is now being put into production in the Chelmsford factory. The first production equipments have now been assembled as a multi-channel radio link between Start Point, Devon, and Galleywood, Essex, a distance of just over 200 miles. This link, which works on a frequency of 858 Mc/s and has an initial capacity of twenty-four telephone channels, is for single-way operation with the transmitter situated at Start Point and the receiver at Galleywood. As at present manufactured the equipment is designed for a maximum of sixty simultaneous telephone channels, but provision has been made for experimental wide-band transmissions to be effected later, with a view to carrying a much greater number of channels. Later, too, television pictures are to be transmitted to ascertain whether an acceptable quality can be realised.

The Start Point transmitter (illustrated below) employs a water-cooled four-cavity Klystron developing an output power of 10kW. The associated aerial system, a 30ft diameter paraboloid " dish " excited by a horn radiator, is mounted with its centre 35ft above ground level as illustrated here. This aerial system has a gain of 36 dB over a dipole at the chosen frequency (858 Mc/s) and thus provides an effective radiated power in the direction of maximum intensity which is of the order of 40MW. The receiving equipment at Galleywood is of the dual diversity type, employing two dish aerials each of 30ft diameter and spaced 100ft apart. This method, it has been found by previous experience, does much to counteract the rapid fading which is a characteristic of tropospheric-scatter working.

Work done with this equipment shows that multi-channel tropospheric-scatter links can satisfactorily provide a point-to-point transmission of signals over distances of 200 miles or more as compared with the 40-mile average of direct-beam systems. Although in some cases it may be more expensive, the tropospheric-scatter method holds out great possibilities over routes where intermediate repeater stations are impracticable, as over desert or long expanses of water.

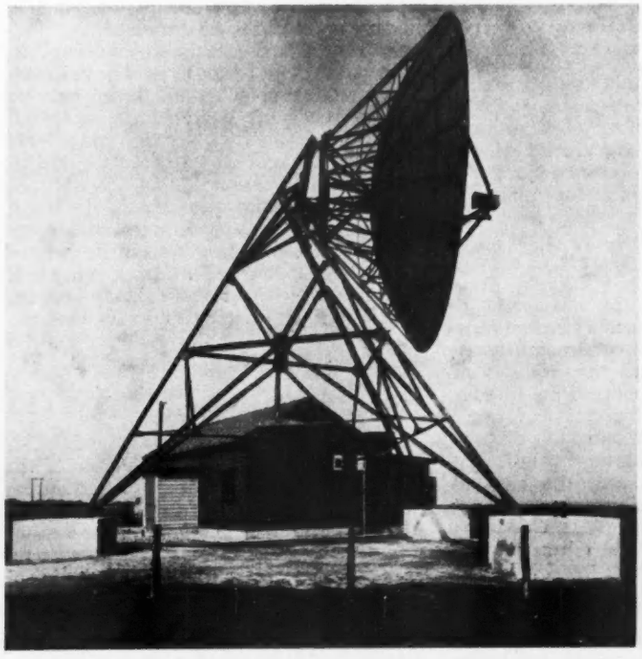
* The basis of propagation by tropospheric-scatter is that, if radio waves are directed into the upper atmosphere (troposphere), where " scattering " occurs, part of the energy is directed forward and downward and reaches the earth again at a point remote from the transmitter. This principle promises to be useful for radio communication at frequencies up to 10,000 Mc/s. See THE ENGINEER, October 26, 1956, page 595.

Submarine Power Cable for New Zealand

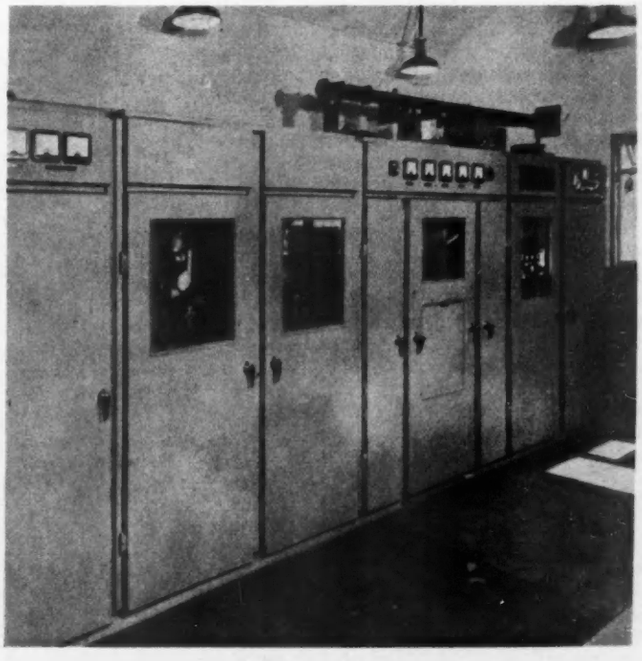
THE practicability of linking the rich electric power resources of New Zealand's South Island with the supply network of the industrial North Island has been under investigation for nearly two years by the B.I.C.C. group of companies. This investigation resulted in an announcement on Monday, April 28, by Mr. H. Watt, the Minister in Charge of the New Zealand State Hydro Electric Department, that the B.I.C.C. group is to lay, test and recover a trial length of cable to provide data for the ultimate installation of a submarine power cable across Cook Strait. The trial cable, half a mile long and 5in in overall diameter, was manufactured at the works of British Insulated Callender's (Submarine Cables), Ltd., Trafford Park, Manchester ; it is a single-core pre-impregnated high-pressure gas-filled cable, and is to operate at 250kV d.c. It has a hollow copper conductor, is paper insulated and lead sheathed, and is suitably reinforced with steel tapes and steel wire armouring to withstand the particular conditions of the sea bed under Cook Strait. This trial cable was not of sufficient length to warrant transport by a cable-ship. The cable was, therefore, coiled on a drum 15ft 8in in diameter and 7ft 6in across, which, with the cable, weighed about 45 tons. It left Trafford Park Works on February 24, was loaded aboard the s.s. " Carronpark " at Liverpool, and arrived in Wellington, New Zealand, on April 16.

Under the supervision of engineers from British Insulated Callender's Construction Company, Ltd., the trial length will be laid by the New Zealand Post and Telegraph Department's cable-ship H.M.T.S. " Matai " seawards from Oteranga Bay, which is on the North Island shore of Cook Strait south of Cape Terawhiti. After the ends have been sealed, the cable will be anchored and allowed to remain on the sea bed for as long as possible.

For a full-length power cable the projected Cook Strait crossing route is about 25 miles long, with a maximum depth of 150 fathoms.



30ft diameter dish aerial at Start Point (Devon), one terminal of a tropospheric link with Galleywood (Essex) 200 miles away



This high-power transmitter at Start Point is designed to provide an effective radiated power, in the direction of maximum intensity, of 40MW

Industrial and Labour Notes

London's Bus Strike

At midnight last Sunday, the bus, trolleybus and coach drivers and conductors and garage staff of London Transport began a strike called by the Transport and General Workers' Union. The dispute dates back to last October, when the union put forward a claim for a general wage increase of 25s. a week for its 50,000 members in the operating and maintenance grades of London Transport's road services. The London Transport executive rejected this claim and, subsequently, both parties agreed that it should be submitted to the Industrial Court for arbitration. The Court's award was an increase of 8s. 6d. a week to the 36,000 drivers and conductors on the "central" road services (red buses and trolleybuses) and no increase to the operating staffs of the country bus and coach services or to the garage and depot maintenance staffs. London Transport offered to meet this award immediately it was announced in March, but the union rejected the offer and asked for an all-round increase of 10s. 6d. a week. This demand was followed by notice of a strike timed to begin at midnight on May 4.

On April 28, the London Transport Executive invited the union's negotiating committee to a further meeting. The executive then offered, if the union would accept the Industrial Court's award, to examine in the autumn, in the light of circumstances then existing, the wage rates of all grades of staff covered by the application to whom no award had been made, and to review at an earlier date the wages of Green Line coach drivers who work through the congested areas of Central London. The autumn review, London Transport said, would include a joint examination of the means of securing the most economical operation and maintenance of the road services. This proposal was rejected by the union's negotiating committee, which then asked for an immediate increase of 6s. 6d. a week to all grades of staff covered by the application, plus a further review later in the year of the pay of all grades involved. The London Transport executive could not accept that suggestion as it set aside completely the Industrial Court's award.

During last week, the Minister of Labour was pressed to intervene in the dispute. He explained in the House of Commons on Friday that he could not take any action which would have the effect of seeking to vary an award of the Industrial Court. In answer to questions addressed to him on Monday, the Minister expressed his regret that the union had not accepted the Industrial Court's unanimous award. He added that, in consultation with his advisers, he would decide if and when any intervention by himself would be useful.

On Wednesday, the finance and general purposes committee of the Trades Union Congress was summoned to consider the implications of the strike. Yesterday (Thursday), in the House of Commons, an Opposition motion was tabled for debate "deploring the refusal of the Minister of Labour, in pursuance of the economic and industrial policy of the Government, to attempt to bring about a settlement."

Engineering Wages

On Thursday of last week, the national committee of the Amalgamated Engineering Union, at its annual meeting, discussed resolutions about wages. The debate was in private session, but it was stated afterwards that there was a unanimous decision to make an immediate demand for a substantial wage increase for engineering and shipbuilding workers. The resolution, it is understood, urged that there should be no "strings" attached to an award resulting from the claim and that the negotiations should not take longer than three months.

It will be recalled that when the last wage increase was granted to engineering and shipbuilding workers in May, 1957, the unions agreed not to put forward another claim for a year. They also agreed that they would endeavour to stop unofficial strikes and embargoes on overtime, to encourage the acceptance of new machines and techniques, and to encourage their members to observe strictly the times appointed for starting and stopping work.

The wage "standstill" undertaking expires at the end of this month. During the past year, the unions have put forward claims for a forty-hour week, without loss of pay, which have so far been rejected by engineering and shipbuilding employers. Further approaches on this subject are now being made, the A.E.U. national committee having passed a resolution demanding that the forty-hour week claim should be pressed with the "utmost vigour." The wages resolution has to go to the Confederation of Shipbuilding and Engineering Unions—of which the A.E.U. is a powerful constituent—before any further action on it is possible. The Confederation has the responsibility of formulating a claim.

Railway Economies and Wages

Further meetings have been held this week between Sir Brian Robertson, chairman of the British Transport Commission, Mr. Harold Watkinson, Minister of Transport, and representatives of the three railway unions on proposals concerned with the more economic and efficient operation of British Railways. These proposals have been formulated in the hope that they might make possible a review later this year of railway wages and salaries.

The British Transport Commission's suggestions and the Government's views on them were announced in correspondence between Sir Brian Robertson and the Minister of Transport, which was published on Tuesday evening. The economy measures put forward by Sir Brian include : a reduction of train mileage, incorporating adjustments in freight services, to correspond with the level of freight traffic, and cuts in passenger services; the scrapping this year of 100,000 wagons ; a reduction of maintenance expenditure on buildings and rolling stock ; the withdrawal of services from more than thirty lines, thereby effecting an annual saving of £500,000 ; the stopping of the Newhaven–Dieppe Channel service in winter, and reductions in other cross-channel services, and substantial economies in manpower. The Minister of Transport's reply to these proposals indicates the Government's willingness, provided the unions will support the measures, to authorise additional investment of £25,000,000 during 1958 and 1959 so that the Commission may accelerate the more remunerative items in its modernisation programme. According to Sir Brian Robertson, this £25,000,000 would be spent on projects likely to yield a "quick return." They include : £7,000,000 to avoid slowing down in the programme for new works and plant in 1958 and 1959 ; £6,000,000 for diesel locomotives and multiple-unit trains, and £12,000,000 for projects giving a rapid financial return, such as the contraction of marshalling yards and the modernisation of goods depots, more facilities for diesels, and the improvement of signalling systems.

As these notes go to press, Sir Brian Robertson is having more discussions with representatives of the three unions—the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Transport Salaried Staffs Association. The union executives met on Tuesday evening, and it was stated afterwards that their intention was to see if they could get an immediate improvement in the rates of railwaymen's pay.

Trade and Wage Demands

At the annual general meeting last Tuesday, of the London Chamber of Commerce, the retiring president, Sir Edward Chadwyck-Healey, Bt., briefly reviewed the Chamber's principal activities during the last twelve months. In his address, Sir Edward stressed that the gold and dollar drain on Britain in her capacity of sterling banker clearly had to be overcome at however great an inconvenience to trader and merchant, and, he added, the talking down of British capacity to live, work and produce in this modern world had to be disproved.

Sir Edward said that the strong line taken by the Government had, so far, been successful in rebuilding gold and dollar reserves beyond the danger limit, but not yet much beyond if devaluation of the pound was never again to rear its ugly head. It was to be hoped, he continued, that the ill-timed demands for higher wages would not again put British interests into reverse and lower her reputation for shrewdness in the eyes of the world. Of course, Sir Edward remarked, the time for higher wages would come again, especially when output was on the increase, but to press for it at this juncture was not in the true interest of anybody.

Shipbuilding Statistics

The statistics issued by the Shipbuilding Conference for the first quarter of the year show that the new orders placed during the period amounted to thirty-nine ships of 41,000 gross tons, which brought the total of new orders booked in the twelve months up to March 31, 1958, up to 207 ships of 1,120,000 gross tons. The order book at the end of March consisted of 765 ships of 6,331,000 gross tons and valued at £900 million. No contracts were booked for foreign account during the quarter, but the export proportion of the total order book amounted to 20 per cent.

German Industries Fair, Hanover

No. II—(*Continued from page* 673, *May* 2)

Opening Ceremonies

ON Saturday evening, April 26, an informal dinner was held in the main restaurant, given by the Deutsche Messe und Austellungs A.G., to welcome exhibitors and the Press, and about 800 persons were present. The guests were warmly welcomed by Minister Alfred Kubel, chairman of the Board of Supervision of the Messe A.G. During the evening, Dr. Schneider, Minister of Economics in the Saar, spoke at some length on the differences of wages and family allowances in France and Germany, and expressed the hope that a careful consideration of these and other problems would eventually lead to the establishment of a common market and free trade in Europe.

New southern entrance, showing new halls for electrical engineering exhibits

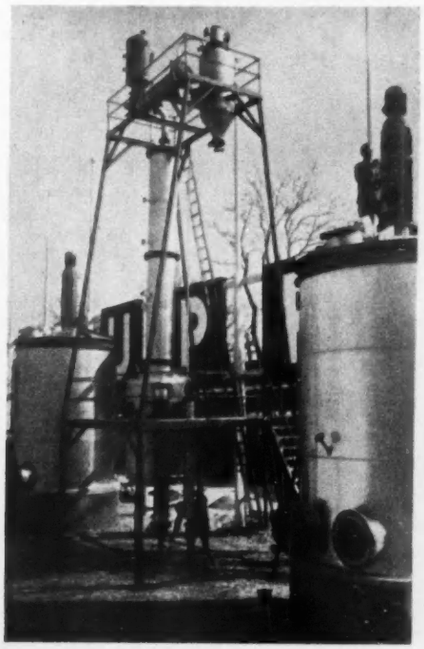
On Sunday morning, April 27, the festive opening of the Fair took place in the Niedersachen Hall, Hanover. The Niedersächische Symphony Orchestra, conducted by Dr. Helmuth Thierfelder, was present and opened the proceedings with Handel's Festival Overture in D. Minister Alfred Kubel again welcomed all present on behalf of the Deutsche Messe und Austellungs A.G. and handed to Dr. Heinz Thörner, the chairman of the Central Organisation of the Electro-Technical Industry, the key of the newly completed buildings for the electrical industry Dr. Thörner expressed his thanks on behalf of the industry for the excellent exhibition accommodation which had been provided, and spoke on outstanding developments in recent years which had brought prosperity to the electro-technical industry. Dr.-Ing. Hans-Christoph Seebohn, Minister of Transport, then described the show of aeroplanes and aeronautic fittings and equipment which, during the Fair, had been arranged at the Hanover Airport. The Fair and the Aeronautical Exhibition was then officially declared open by Professor Dr. Theodor Heuss, President of the Federal Republic of Germany. Dr. Heuss made reference to the speech he made seven years ago, and he outlined the progress made by the Messe A.G. in the development of the Fair.

British Atomic Energy Exhibit

British atomic energy achievements were on show for the second time on the joint United Kingdom Atomic Energy Authority - Nuclear Energy Trade Associations Conference stand in Hall 3. This was a commercial stand covering all types of nuclear equipment for peaceful purposes, from a £20 nucleonic instrument to a £20,000,000 nuclear power station. In addition to supplying nuclear equipment, by British private industry, the United Kingdom Atomic Energy Authority also demonstrated the various types of uranium fuel elements which they are offering for sale to power British type reactors overseas. The fuel service offered is fully comprehensive direct from the Authority's works to the overseas customers, including a reprocessing service after use. One of the most popular exhibits on view was a reactor-simulator, which was specially brought over to Germany to enable professors and technical experts to try putting on load a nuclear power unit, similar to those at Berkeley, Bradwell, Hinkley Point and Hunterston. On the opening day, Sunday, April 27, a conference of friends and the Press heard two excellent addresses, one from Sir William Cook, of the Atomic Energy Authority, and the other from Mr. J. K. Vaughan-Morgan, Minister of State, Board of Trade, who explained the purpose of the exhibit.

Hoesch Werke A.G. Dortmund

On the stand of the Hoesch Werke A.G. of Dortmund, there was shown for the first time an entirely new development in the manufacture of pipes for gas, oil, water and piling, by spiral welding. The principle employed is clearly shown in the accompanying illustration, from the foreground of which, it will be seen that the process consists of bending steel strip with the longitudinal edges sheared parallel, thereby forming a continuous spiral, which is welded along the longitudinal contacting edges of the strip. The type of welding employed is automatic submerged arc welding, two welding passes being made, one inside and the other outside the pipe. By these means, a straight pipe with a true circular section is produced, having a spirally welded seam. The pipes can be made in unlimited lengths.



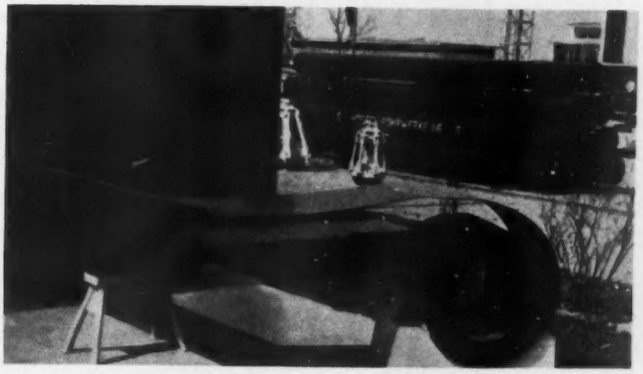
Part of chemical plant for Russia made of "Nirosta VA4" extra rustless steel—Fried Krupp

The hydraulic tests made on the bursting and flattening of the pipe all show that the physical and mechanical properties of the pipe are excellent, and the X-ray tests made show continually sound welded metal. In the tensile test already carried out with the welded seam in the transverse direction, it is shown that failure takes place in the plate itself, and not in the welded seam. The spiral seam is from the stress point of view in a more favourable position, and the directional properties of the steel strip are located at a more desirable angle.

These new pipes are now manufactured with outside diameters from 20in up to 46in, having minimum and maximum wall thicknesses of $^{5}/_{32}$in and $\frac{3}{8}$in for the smallest. The weights are 33·39 lb and 78·44 lb per foot. With minimum and maximum wall thicknesses of $\frac{3}{16}$in and $\frac{3}{8}$in the 46in diameter pipe has weights of 92·49 lb and 182·34 lb per square inch. These spirally welded pipes are manufactured at the works of the Hoesch Rohrwerke A.G. at Hiltrup, Westphalia.

Fried Krupp

This year, part of the large stand of Fried Krupp, of Essen, was enclosed by a section of



Spiral welded pipes—Hoesch Rohrwerke A.G. Hiltrup, Westphalia

Cable sheathing extrusion press ; maximum pressure 2500 tons—Fried Krupp

steel piling having a height of 10m and a length of 20m.

On the other side of the stand was the chemical plant shown on page 711 which forms part of an order for a chemical plant designed to produce the basic materials for the manufacture of synthetic fibres. The plant shown forms part of the order received by Krupps from the Soviet Union. The vessels and pipes shown are all made of special rustless steel, " Nirosta VA4 Extra." In the Krupp pavilion, there were shown several models of new installations ; one of these showed details of the Presque Isle transport centre on Lake Erie, which Krupps are constructing, a ship loading station having a capacity for handling 6000 tons of coal per hour, and which will, it is expected, go into operation in July this year.

A large exhibit which dominates the interior of the pavilion, is the large extrusion press (above) for cable sheathing. This press is of the modern design and is specially intended to permit not only the use of lead as a sheathing material, but also aluminium. This combined lead and aluminium extrusion press develops a maximum press load of 2500 tons, with a pressure in the hydraulic fluid of 400kg per square centimetre. The press is actuated by an oil-hydraulic drive made by Messrs. Towler, of Rodley, which can be used to work pure lead and lead alloys containing up to 1·2 per cent of antimony and up to 4 per cent of tin. The container has a capacity of 450 kg.

Conversion of the press for the extrusion of aluminium sheathing having diameters up to 60mm may be accomplished in the short time of four to six minutes by fitting a specially designed set of tools which permit the use of aluminium having a purity of 99·5 per cent for extrusion purposes.

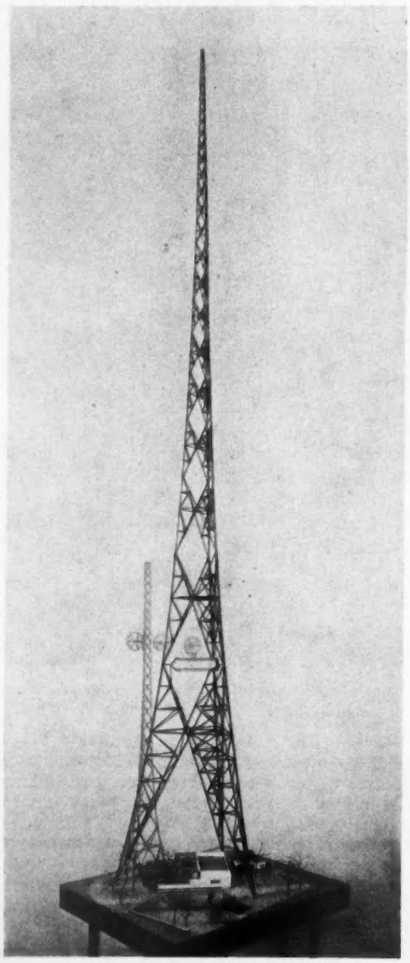
Another notable exhibit on the outer Krupp stand was the new specially designed breakdown crane (below), constructed by the Krupp Ardelt Werke G.m.b.H. of Wilhelmshaven, having a carrying capacity of 15 tons. It has been designed to clear up refuse from accidents, to right overturned trucks and vehicles and to clean up blocked roads, railway tracks and airport strips.

All the working movements of the new crane are actuated by fast, smooth and positive hydraulic power, which is supplied by an oil pump mounted on the upper carriage and driven by the vehicle engine. The lifting and slewing movements are all lever controlled from the driver's platform. There is also provided a long cable with a push-button control which enables the driver to direct operations some distance from the crane. The raising and lowering of the crane jib is effected by two hydraulic cylinders giving a total range of 2·5m.

The crane is also provided with a separate towing boom which is fixed to the rear of the upper casing and is equipped with a 5-ton hand-operated winch. The crane described has a high road speed of 55km per hour which enables it to be moved quickly to the scene of an accident. The new features in design and power control may render it greatly superior to many of the cranes which have been previously employed for accident service.

Mannesmann Aktiengesellschaft

On Monday, April 28, it was officially announced by the Mannesmann Aktiengesellschaft, that shortly after the close of the present Fair, work will commence on the construction and erection of a new Mannesmann tower, which will have a height of 350m. It will be recalled that the present tower on the Mannesmann stand was built in 1954 and that its height is 120m. The two towers are clearly shown in model form on the right. The construction of the new tower will embody the latest developments in light seamless steel Mannesmann tubes. The weight of the present tower with a height of 120m is about 35 tons, but the new 350ft high tower will have a total weight of about 350 tons. In the old tower the distance between the outer edges of the supporting members or feet was about 18m at foundation level and about 2m at the top of the tower. In the new tower these dimensions will be 65m and 1·5m respectively. Seamless tubes of the latest Mannesmann production will be used having a maximum of 546mm and a minimum of 51mm outside diameter, with wall thicknesses of 20mm down to 3mm. It will be seen that the new tower will be about three times as high as the old tower and it is of interest to learn that it will be one of the highest towers in Europe. Comparable towers are the Radio Tower, Berlin, with a height of 135m and the Eiffel Tower in Paris with a height of 300m. The completion of this new tower for next year's German Industries Fair will be awaited with the greatest interest.



Model showing old and new Mannesmann towers—Mannesmann Aktiengesellschaft

(To be concluded)

15-ton breakdown crane—Fried Krupp, Krupp-Ardelt G.m.b.H., Wilhelmshaven

Naval Guided Missiles

In 1951, a Guided Missile Department was established within the Late-Coere Company, under the direction of Mr. M. Moine. The company employs a total personnel of 900 persons, including technicians and workers. It has developed, constructed and perfected guided missiles for the navy, among them the " Malaface " ship-to-ship missile, which has a powder accelerator and a liquid propellant (a nitric acid compound), and the " Masalca," an anti-aircraft defence missile propelled by ram-jet.

American Nuclear Engineering Conference

BY OUR AMERICAN EDITOR

No. III—(*Continued from page 677, May 2*)

The fourth Nuclear Engineering and Science Conference was held at the International Amphitheatre in Chicago, Illinois, from March 17 to 21, in conjunction with the 1958 "*Atomfair*" *exhibition. The conference was organised under the sponsorship of the American Nuclear Society in co-operation with twenty-eight other American and Canadian engineering institutions. The exhibition was sponsored by the Atomic Industrial Forum and presented a comprehensive picture of the current state of development in the application of atomic energy in American industry.*

Babcock and Wilcox Company

THE exhibit of the Babcock and Wilcox Company, of New York, stressed the N.S. "Savannah," the first American nuclear-powered merchant vessel, for which the firm is developing and constructing the nuclear propulsion system.

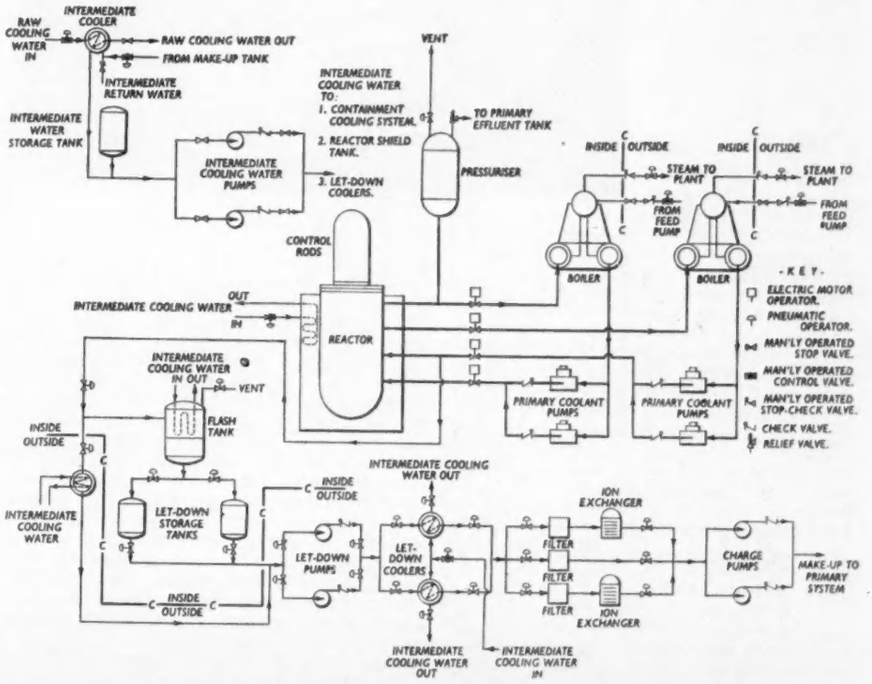
The vessel itself has been designed by the firm of George G. Sharp, Incorporated, and we depict a scale model of the ship. The vessel is of the passenger-cargo type, designed on the shelter-deck principle with raked stem and modified cruiser stern. There are three complete decks, "A," "B," and "C," with cargo platforms and deep tanks at various levels below. A promenade deck extends over the "A" deck for about one-third of the ship's length from a point slightly forward of amidships. Above this is a shorter boat deck and navigating bridge deck. There is an inner bottom providing tanks which will be used for clean ballast when required, diesel oil and distilled water. The thirty passenger state rooms are situated on "A" deck. The public rooms, including the main lounge, library, writing room, card room, bar dance area, and cocktail lounge, are arranged one deck above on the promenade deck. The dining room is situated on "B" deck. The swimming pool and passenger play area are on the promenade deck aft of the public rooms. The hull is subdivided by ten water-tight transverse bulkheads into two peak spaces, seven cargo holds, an engine-room and a reactor space. The ship and its machinery will be designed and built to the approval of the Maritime Administration, the American Bureau of Shipping, the United States Coast Guard, and other regulatory bodies.

The N.S. "Savannah" will have an overall length of 587ft 6in, a beam of 78ft, a design draught of 29ft 6 in, a full load displacement of 21,840 tons, a design speed of 20·25 knots, a maximum continuous power of 22,000 s.h.p. and a cruising radius of 350,000 miles. In designing the propulsion plant, the following special safety principles were observed: (1) Operation of the plant, even at full power, shall not be impaired by the failure of any fuel elements. (2) If the reactor is shut down for any reason, at least two sources of power shall be available to remove its decay heat. (3) No operation or failure of the reactor plant at sea shall require any of the crew to enter the reactor compartment, or to be exposed to harmful radiation, in order to bring the ship home.

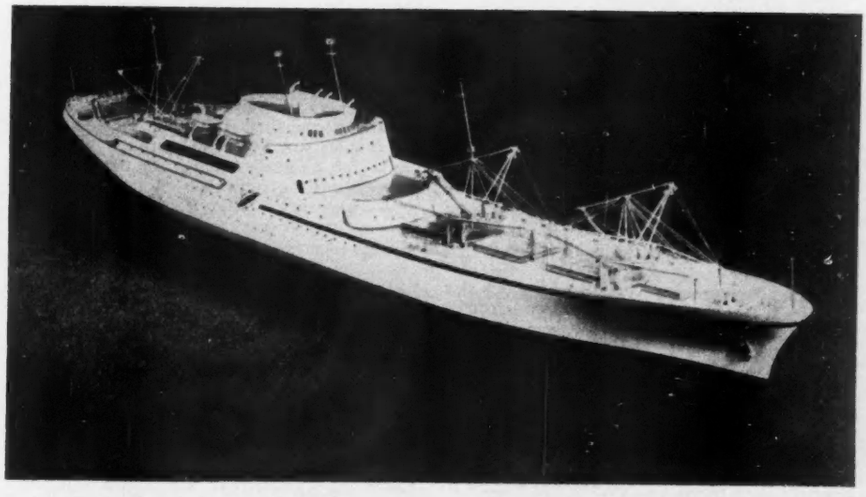
The power plant has been designed to furnish a maximum continuous power of 22,000 s.h.p. to a single propeller and auxiliary power equipment. At this load reactor cooling is provided by four primary circulating pumps. It is possible to design for a normal power of 20,000 s.h.p. with only two reactor circulating pumps in use. The principal elements comprising the power plant are: (1) A reactor system containing a single reactor with two main cooling loops and two steam generators. (2) A propulsion system consisting of a high- and low-pressure turbine geared to a single propeller shaft and to two auxiliary turbo-generator units. (3) An electrical distribution system to supply all ship's and plant auxiliaries. (4) Control systems for power plant control and operation. (5) All associated auxiliary systems. The steam generators are cross-connected to supply both the main turbines and the auxiliary turbo-generator units simultaneously or independently.

As shown below, the reactor plant consists of a reactor-cooling system, referred to as the primary cooling system, and auxiliary systems which serve the primary system such as the pressuriser, intermediate-cooling, purification and reactor-control and instrumentation systems. The primary cooling system contains the basic power-producing components, which include the reactor and two loops each containing a steam generator, two primary circulating pumps, valves, and inter-connecting piping. The major portion of the reactor system is enclosed within a sealed and shielded containment vessel designed to contain the products of any rupture in the reactor system during operation.

The reactor pressure vessel will consist of a cylindrical shell about 98in i.d., with a hemispherical head at the bottom and a spherical dished head on top. The bottom head will be welded to the shell, and the top head will be attached to the shell through a flange by bolts uniformly tightened. The flange will be sealed with a double gasket and a seal weld. The entire vessel will be of carbon steel, clad on the inner surface with stainless steel. The vessel will have an insulating jacket on the outside consisting of 3in of stainless steel wool. Outside this will be the primary shield consisting of about 33in of water in an annular tank, with about 3in of outer lead. Water will enter the reactor vessel through two nozzles, about 14in i.d., and leave through two similar exit nozzles. The thermal



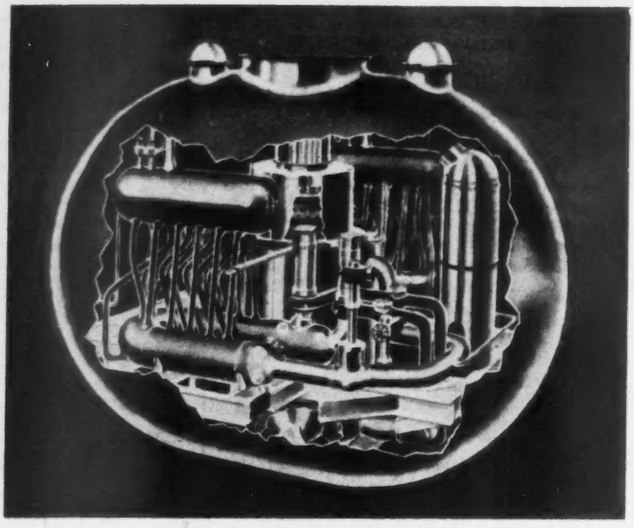
Flow diagram of nuclear reactor plant for N.S. "Savannah"



Scale model of N.S. "Savannah," the first American nuclear-powered merchant vessel

shielding will consist of a number of steel plates surrounding the core in the outer reflecting water annulus having a total thickness of 15in of water and steel. The reactor vessel and all parts in the primary loop will operate under an internal pressure of 1750 lb per square inch, but will be designed for a pressure of 2000 lb per square inch. The operating temperature will never exceed 530 deg. Fah., except in the pressuriser.

The reactor core, which utilises rods filled with UO^2 with low enrichment, embodies a number of improvements over any previous reactor for marine development. More rugged, less susceptible to burnout, inert to water and more economical, this core is believed to offer great scope for future economical development. The contemplated reactor core will consist of an assembly of thirty-two fuel elements each containing about 200 ½in diameter stainless steel fuel rods filled with uranium oxide having an enrichment of approximately 3 per cent of U-235. Each fuel element will have a 90in length between grid plates. The elements will be situated on close spacing in a right circular cylinder approximately 5ft 6in in diameter. The excess reactivity of the reactor will be controlled by twenty-one control rods. The core lifetime is estimated to be about 52,300MW-days. At the expected operating conditions this will give a period between re-fuelling of approximately 3½ years.



Artist's impression of the reactor primary system with twin steam generators

The fuel element design for the merchant ship employs full length fuel rods. The individual rods will contain unground uranium dioxide pellets, 0·4425in o.d., pressed and sintered to 85 per cent of theoretical density. The cladding will consist of a 0·5in o.d. Type 304 stainless steel tube with 0·026in wall thickness. The gap between fuel pellet and tube wall will contain helium gas which is introduced during the end plug welding process. Each fuel element will contain 196 rods in a square array. The centre-to-centre spacing of the rods will be 0·612in, giving an overall metal to water ratio of 0·97. The rod spacing will be maintained by small stainless steel ferrules brazed in place every 8in. An extensive development programme aimed at the improvement of the fabrication technique and consequent reduction in fabrication cost is now under way at the Babcock and Wilcox Alliance Research Centre and the Lynchburg Nuclear Facilities plant.

The reactor will have three water-flow passes ; an outer or first pass, having up flow through the thermal shields ; a second pass down through the outer portion of the core, and a third pass up through the centre of the core. At 85MW output, primary cooling water will enter the reactor at a temperature of 521 deg. Fah. A mean water temperature of 508 deg. Fah. will be maintained through the reactor at all loads. The operating pressure of 1750 lb per square inch will also be maintained in the reactor at all loads so that local boiling will not occur in the core during normal transients.

The reactor primary system, shown on this page, will transfer the heat from the reactor to two steam generators by means of pressurised water flowing through two parallel loops. The water will be circulated by two vertical primary circulating pumps in parallel in each loop downstream of the boiler. The motor on each pump will be equipped with an auxiliary half-speed winding connected to the bus to provide adequate emergency cooling in the event of reactor shutdowns. Each pipeline connecting the reactor to a boiler will contain one remotely operated stop valve. The line on the discharge side of each primary pump will contain a non-return valve. Each non-return valve will be designed to permit a small amount of backflow to maintain the pump, valve and piping at loop temperature when the pump is not operating. The pump discharge lines, in each loop, will then join in a single pipe returning to the reactor. This pipe will also contain a remotely operated stop valve.

The function of the pressurising system is to maintain a controlled pressure in the primary system under both steady-state and transient operating conditions and to allow for variation in volume in the system over the temperature range. The function of the pressure relief system is to provide automatic protection against excessive pressure in the primary system without allowing the system pressure to decrease to a value that would endanger the reactor core. The pressuriser will be connected by a surge line to the reactor outlet piping and will be sized to accommodate the maximum expected rate of change in volume of the primary system. It will be equipped with electric heaters having sufficient capacity to raise the pressure of the primary system from atmospheric pressure to operating pressure in approximately four hours. The pressuriser vessel will be equipped with a relief valve to prevent over-pressure. The water level in the pressuriser will be controlled by a let-down valve on the primary loop releasing primary water to the purification system.

The two boilers will be of the natural-circulation type and will be capable of generating the steam required by the turbines at any load with a constant primary water mean temperature of 508 deg. Fah. As the load reduces, the boilers will generate steam at an increased pressure since the reactor mean temperature is held constant. The design pressure on the tube side will be 2000 lb per square inch and on the shell side 800 lb per square inch. Each boiler will consist of a U-shell encasing a U-shaped bundle of tubes. The primary water will enter through one end of the U-shell and pass through the tubes and discharge from the other end of the shell. The steam generated outside of the tubes will pass upward through risers to a steam drum where it will be separated from the water by cyclone separators and steam scrubbers before passing to the turbine.

The function of the primary-water purification system will be to remove dissolved and suspended impurities from the water in order to limit the amount of its induced radioactivity and to prevent fouling of valves, pump volutes, and heat-transfer surfaces. The let-down water first will be discharged into a flash tank where a vapour space and a liquid space will be maintained in equilibrium at a pressure of about 100 lb per square inch. The vapour space will be cooled by coils circulating "intermediate" cooling water at about 110 deg. Fah. which will in turn be cooled by sea water in the intermediate heat exchanger situated outside the containment vessel. By controlling the flow through coils in the flash tank a constant let-down pressure can be maintained. Downstream of the flash tank the let-down flow will be further cooled in let-down coolers to about 110 deg. Fah. before passing through the filters and ion exchangers. The let-down filters connected in parallel will remove the undissolved solids, one serving each ion exchanger. The two mixed bed ion exchangers, also connected in parallel, will remove the soluble impurities, except the gases. From the ion exchanger the let-down flow will combine with whatever make-up is required from the feed-water system and enter the charge pumps which will restore it to the primary system.

The nucleus of the containment vessel circulating air system will be a finned cooling coil and denumidification system which will be capable of removing the heat liberated from the face of the insulating surfaces, while maintaining the temperature and humidity within acceptable values for the equipment situated inside of the containment. The moisture removed from the containment vessel air will be drained to the containment bilge. A separate ventilating system will be used to purge the containment vessel before it is entered after shut-down.

The function of the instrumentation and control system of the nuclear plant will be to furnish indication, alarms and control signals for the various system parameters such as pressure, temperatures and flow. The instruments will consist of sensing elements, amplifiers and meters. The control for the nuclear steam generating system will be a constant-flow primary system and a constant average reactor temperature. The reactor demand signal will be anticipated from the change in steam flow, which will be corrected for the pressure variations.

The propulsion system embodies a high- and low-pressure turbine with a steam separator situated in the cross-over line. The power is to be divided approximately equally between the two units at full power. Both uncontrolled and controlled nozzle arrangements will be incorporated. The turbines will be designed to operate at 20,000 s.h.p. with saturated steam as low as 415 lb per square inch and 28in Hg vacuum in the condenser. In the event of emergency shut-down of one of the steam generators, sufficient steam for 85 per cent of normal power can be maintained to the propulsion turbines. The steam turbines drive the propeller shaft through double-reduction gears. This system includes a main and two auxiliary condensers with the usual auxiliaries and three feed-water heaters. The two 1500kW auxiliary turbo-generators provide sufficient power to drive the primary cooling pumps in the reactor system, other propulsive loads and the ship's service and hotel loads. Emergency power for ship's services and reactor cooling will be furnished by two 750kW diesel generators. Emergency take-home shaft power is supplied by a 750 h.p. motor on the main reduction gear. Emergency steam for heat and fire protection and main condenser air ejection will be furnished by a package boiler.

A low-pressure steam-generating system will furnish auxiliary and ship's service steam. Steam from the main steam drum will be bled to the low-pressure steam generator to furnish the heat necessary to produce this steam at a pressure of 150 lb per square inch gauge. This extra precaution has been taken to prevent any possible contamination of the low-pressure steam with any radioactive material. Condensate from the low-pressure generator is discharged through a drain cooler to the deærating feed heater.

The Maritime Administration and the Atomic Energy Commission have awarded a 21,000,000 dollar contract for the construction of the ship to the New York Shipbuilding Corporation, of Camden, New Jersey. The keel for the vessel will be laid on May 22, launching is scheduled for 1959 and the ship should commence operations in 1960.

Atomics International

The highlight of the display by Atomics International, Division of North American Aviation, Incorporated, of Canoga Park, California, was a 100MW atomic power station

using an Organic Moderated Reactor (OMR). This reactor concept has been developed by the firm as part of the A.E.C. programme for the development of economic nuclear power. The original 16MW Organic Moderated Reactor Experiment (OMRE), which is illustrated here, was designed and built to verify preliminary experiments which had demonstrated the feasibility of employing an organic as a reactor moderator, reflector and heat transfer medium. A further objective was to study the rate of decomposition of organic coolants under continued effects of heat and radiation in an operating reactor, and to develop operating conditions and purification methods to maintain satisfactory organic compositions. Engineering design work was begun in the summer of 1955 and ground was broken for site construction on June 17, 1956. The reactor attained criticality on September 17, 1957, and began full-power operation in February, 1958. The OMRE is believed to be the world's first reactor to use an organic liquid as a moderator, reflector and heat transfer medium.

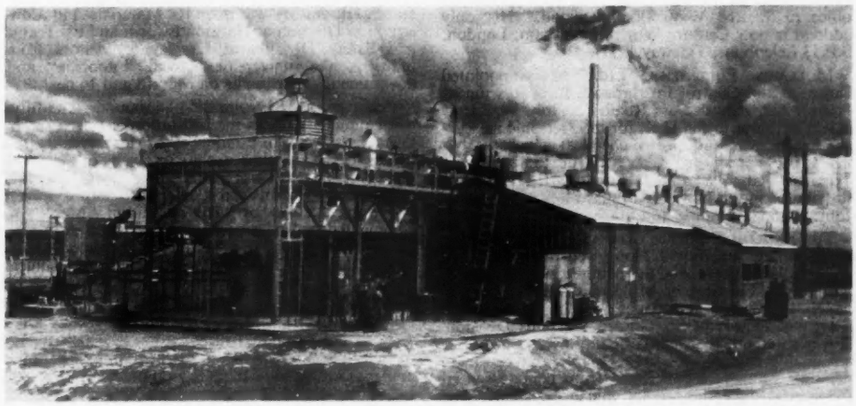
In the opinion of the company, the satisfactory operating experience with the OMRE provides a sound basis for an immediate application of the Organic Moderated Reactor to large power stations. A nuclear power station employing the OMR system has many advantages. The reactor and the heat transfer systems operate at low pressure and yet achieve relatively high temperatures. Furthermore, the absence of corrosion between the organic and ordinary materials of construction allows the use of carbon steel and aluminium in the manufacture of the reactor and heat transfer system components. This results in conventional manufacturing methods and low-cost construction. Also, because of the low system pressure, the chemical properties of the organic and the inherent safety characteristics of this reactor concept, no special containment building is required to house the reactor. Finally, the low induced level of radioactivity in the organic results in simplified, safe, low-cost maintenance. The nuclear power plant now being offered by the firm is based on a saturated steam cycle as noted in the plant data, column (1) below. Similar data for a plant based on a superheated steam cycle are shown in column (2) below.

Data for Alternative Steam Cycles

	(1)	(2)
Rated net electrical output	100MW	100MW
Rated gross electrical output	108MW	108MW
Reactor designed thermal output	370MW	381MW
Steam pressure at turbine	615 lb per square inch absolute	415 lb per square inch absolute
Steam temperature at turbine	489 deg. Fah.	550 deg. Fah.
Feed-water temperature	376 deg. Fah.	357 deg. Fah.
Steam flow at nominal power	1,470,000 lb per hour	1,370,000 lb per hour
Turbine exhaust pressure	1·5in Hg	1·5in Hg
Net heat rate	12,600 B.Th.U. per kWh	13,000 B.Th.U. per kWh

In the proposed power station the reactor and turbo-generator are housed in the main building, which is approximately 280ft long, 92ft wide and 80ft high. A bridge crane serves the entire length of the building. A concrete wall encloses the reactor and turbine area from the other parts of the plant. The reactor itself, together with the coolant piping and heat exchanger equipment, is contained in cells below ground level. There are four steam generators and four parallel heat transfer loops. In each loop the organic coolant is pumped from the reactor vessel to the steam generator and back to the reactor. The control room is situated on the first floor of the two-storey building and permits observation of both the reactor and turbine areas.

Normal plant operation is controlled from a central control room. The organic transfers heat from the reactor to the four steam generators. Steam from the steam generators flows to a common header which serves a single turbo-generator. Steam is extracted at three stages to heat feed water. The plant is controlled at a constant steam pressure maintained throughout the load. Reactor power is controlled from neutron flux and organic outlet temperature data. Reactor outlet temperature signals to the reactor controller are modified by steam pressure-flow instrumentation to adjust the reactor thermal power load demand. The negative temperature and power coefficients of reactivity eliminate the need for fast reactivity control and small transients are nullified by the temperature coefficient.



Organic Moderated Reactor Experiment (OMRE) of 16MW capacity designed and built by Atomics International in Idaho

The main heat transfer lines are of carbon steel. The main organic pumps are carbon steel centrifugal pumps with mechanical, water-cooled shaft seals. A shell-and-tube steam generator with an integral steam separator is used with steam and water on the shell side and with organic flowing in the tubes.

A degasification and pressurisation system removes dissolved gases formed by decomposition of the organic and provides for its expansion. A pressure-relief system protects the reactor system in cases of large water or steam leaks to the organic side. The drain tanks are sized to hold the contents of the core tank and two of the four heat transfer loops to permit maintenance or repair work, if necessary. The residues formed in the organic are continuously removed in a purification system by a flash still and distillation column. Non-condensible gases from the degasifier and purification system normally flow into the gas scrubber and out through the stack. If radioactivity should exceed permissible values, the gas flow is diverted to gas hold-up tanks and is allowed to decay before exhausting to the stack.

The reactor vessel is made of low carbon steel and has a tank wall thickness of 2in. The reactor core is situated below ground level. It is surrounded radially by an inner thermal shield, a steel reactor tank, an outer thermal shield, thermal insulation, a steel cavity liner and concrete. The shielding above the core consists of the steel upper grid plate, 25ft of organic and a 6in thick steel top head. Ordinary concrete is the basic shielding material around the reactor, the main heat transfer loops and the organic process systems.

The reactor core contains 287 finned plate type fuel elements. Each finned plate consists of a slightly enriched uranium plate jacketed by an extended surface aluminium cladding. These fuel plates are contained in a steel box with a fuel handling fitting at the top and a locating fitting at the bottom. The entire fuel element hangs from an upper grid plate and is restrained by the bottom fitting which extends into a lower grid plate. Each element is provided with individual orifices to obtain a maximum bulk organic outlet temperature.

The organic is a liquid hydrocarbon called terphenyl. Commercially available terphenyl is a mixture of isomers with a melting point range of 230 deg. to 300 deg. Fah., depending upon the composition. Its boiling point range at atmospheric pressure is 700 deg. to 800 deg. Fah. The boiling point of the mixture used in this 100MW design, at the core system pressure of 120 lb per square inch, is 950 deg. Fah. The organic acts as moderator and reflector in the reactor and also performs as the heat transfer medium between the reactor and the steam generators. It circulates through the reactor, flowing downward through the fuel elements and then upward in the annular space between the inner thermal shield and the reactor vessel. It leaves the reactor via the four outlet coolant nozzles.

A total of sixteen control rods regulate the reactor and provide for emergency shut-down. Each rod, consisting of the absorbing element, rod drive and position indicator, is arranged in a compact assembly that can be inserted in a standard fuel element channel in the core. All moving parts of the control rod are within a sealed tube. The release of a safety element to shut down the reactor is accomplished whenever the current supply to the drive is interrupted. The rod falls by gravity into the reactor core.

The company feels that the features inherent in an organic moderated reactor and those incorporated in this particular design combine to produce a reactor power plant with excellent safety characteristics. The reactor and its organic systems operate under low pressure. The operating temperature of the organic is below its boiling point at atmospheric pressure. The negative temperature coefficient of reactivity of the organic gives the reactor an inherent tendency to resist increases in temperature and power level. Furthermore, the organic is chemically compatible with all materials used in the reactor. In addition, specially designed instrumentation and control systems ensure the obtaining of proper operating data for the safe and efficient operation of the plant. Interlock control systems prevent operating practices dangerous to the plant. The control and instrument systems are designed to be "fail-safe."

(To be continued)

Tripled Output of Experimental Boiling Water Reactor

THE Experimental Boiling Water Reactor (EBWR) at the Argonne National Laboratory of the Atomic Energy Commission, at Lemont, Illinois, was successfully operated at a power level of 62MW of heat in experiments on March 20, 1958. This operating level is more than triple the original design operating level of 20MW. In December, 1957, the EBWR was operated in experiments at 50MW of heat. The increase in the thermal output of the EBWR is a result of months of experimentation. Such an increase would increase the amount and reduce the unit cost of electricity produced by the plant if increased generating capacity were installed. Both the 50MW and 62MW operating levels were achieved without any change in the number of nuclear fuel elements within the core of the reactor.

The EBWR was described in some detail in these columns on April 19 and 26, and May 3, 1957.

Personal and Business

Appointments

MR. R. W. STOREY, A.I.E.E., has been appointed sales manager of Westool, Ltd.

MR. F. O. ACKROYD, A.M.I.Mech.E., has been appointed a director of Crofts (Engineers), Ltd.

MR. T. D. A. CAUNT has been appointed London area sales representative for Fred Myers, Ltd.

MR. IAN MACLEOD-SMITH has been appointed a special director of W. H. Dorman and Co., Ltd.

MR. A. E. CURTIS and MR. N. C. HODSON have been appointed directors of Aldridge Plastics, Ltd.

MR. H. W. FENDER has been elected chairman of the British Chemical Plant Manufacturers' Association.

PETROFINA (GT. BRITAIN), Ltd., announces that Sir Norman Hulbert, M.P., has been appointed a director.

MR. T. A. ROGERS has been elected president of the Institution of Mining Engineers for the year 1959–60.

VICE-ADMIRAL SIR FRANK MASON, K.C.B., has joined the board of directors of H. W. Kearns and Co., Ltd.

TUBE INVESTMENTS, Ltd., announces that Mr. A. J. S. Aston and Mr. R. D. Young have been appointed directors.

MR. W. NUNN has been appointed export sales manager of the engineers tool division of Brayshaw Furnaces and Tools, Ltd.

MR. EWEN M'EWEN, M.I.Mech.E., has been appointed director of engineering, eastern hemisphere, of Massey-Ferguson, Ltd.

MR. DAVID D. MARSHALL has been re-elected chairman of the British Rubber and Plastics Belting Manufacturers' Association.

MR. P. A. HEARNE has been appointed sales manager of British Oxygen Aro Equipment, Ltd., in succession to Mr. David Ince.

MR. H. S. DAVIDSON, M.I.E.E., has been appointed divisional controller of the south western division of the Central Electricity Generating Board.

MR. D. BIGNOLD has been appointed Midlands and eastern counties technical sales representative for machine tools of Newall Group Sales, Ltd.

SIR PETER G. ROBERTS, Bt., MR. P. J. C. BOVILL, MR. A. M. HOLBEIN and MR. K. E. WALKER have been appointed directors of Ransomes and Rapier, Ltd.

THE BRITISH INSTITUTE OF MANAGEMENT has announced that Lord Verulam has been elected chairman designate and will succeed Mr. Harold Wilmot on July 23.

MR. J. B. CLARKSON has been appointed a director of Clarkson (Engineers), Ltd. He is expecting to leave shortly for Germany to join the subsidiary company, Clarkson G.m.b.H.

MR. E. W. PRIOR has been re-elected chairman of the British Mechanical Rubber Manufacturers' Association, and Mr. J. W. Mann has been re-elected vice-chairman.

THE BRITISH WRAPPED RUBBER HOSE MANUFACTURERS' ASSOCIATION has announced that Mr. D. P. G. Moseley has been re-elected chairman, and Mr. P. L. Sherwood, vice-chairman for 1958–59.

THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH states that Mr. A. E. Seddon and Mr. R. C. H. Russell have been appointed principal scientific officers at the Hydraulics Research Station.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION has announced that Mr. S. S. Carlisle, A.M.I.E.E., has been appointed head of the physics department at the Battersea laboratories. He has been succeeded at Sketty Hall by Mr. W. N. Jenkins, A.M.I.E.E.

VICKERS, Ltd., has announced that Sir Sam H. Brown has been appointed an additional director. Sir Thomas R. Merton, having reached normal retiring age, will vacate his seat on the board of directors at the conclusion of the annual general meeting to be held on June 2.

THE FAIREY AVIATION COMPANY, Ltd., has announced that Mr. Robert L. Lickley, M.I.Mech.E., F.R.Ae.S., technical director and chief engineer, has relinquished the latter of these two appointments. Dr. G. S. Hislop, formerly chief designer (helicopters), has been appointed chief engineer (aircraft), and Mr. L. R. E. Appleton, formerly head of guided weapon design and development, has been appointed chief engineer (Heston).

Business Announcements

MISS VERA NORVICK, assistant secretary, the Electrical Association for Women, is to retire.

MR. A. G. IMHOF, managing director of Alfred Imhof, Ltd., has left this country for a tour of the U.S.A. and Canada.

CHARLES CHURCHILL AND CO., Ltd., announces that Mr. R. Gabriel is visiting Canada and the United States of America.

CHATWOOD-MILNER, Ltd., has established a new division to be known as the sound insulation and nuclear protection division.

CRAVEN BROTHERS (MANCHESTER), Ltd., states that the address of its London office is Bridge House, 181, Queen Victoria Street, E.C.4 (telephone, City 2902).

AUDLEY ENGINEERING COMPANY, Ltd., has transferred its London offices from Caxton Street to 60–61, Trafalgar Square, W.C.2 (telephone, Trafalgar 4401-3).

MR. E. S. EVERITT, managing director of Ruston-Bucyrus, Ltd., left at the beginning of May for a visit to the U.S.A. and Canada. He will return in mid-June.

B. ELLIOTT (MACHINERY), Ltd., has appointed Wickman, Ltd., sole distributors in U.K. and Eire for its "Victoria Victomatic" 0-18 and 2-30 automatic cycle milling machines, as from June 1.

MR. BRUCE M. ADKINS, publicity manager of Elliott Brothers (London), Ltd., has relinquished his office at Elstree Way, Borehamwood. His only address is now Century Works, Lewisham, London, S.E.13 (telephone, Tideway 1271).

MULLARD EQUIPMENT, Ltd., has appointed Research and Control Instruments, Ltd., Instrument House, 207, Kings Cross Road, London, W.C.1, as sole distributor in the U.K. for its electronic measuring instruments and electro-chemical apparatus. It has also appointed Kerry's (Ultrasonics), Ltd., Wharton Road, Stratford, London, E.15, as sole distributor in the U.K. for Mullard low power ultrasonic tinning, cleaning and machining equipment.

THE ENGLISH ELECTRIC COMPANY, Ltd., has concluded an agreement with Honeywell-Brown, Ltd., of Perivale, Middlesex, and the Minneapolis-Honeywell Regulator Company, of Minneapolis, U.S.A., under which Honeywell gyroscopes will be made in the Stevenage factory of the Guided Weapons Division. It is pointed out that inertia-quality gyroscopes form a valuable complement to a Doppler navigator in defining the track vector, apart from being essential for inertial and radio-inertial guidance systems. The gyroscopes to be manufactured initially include the "MIG" (miniature integrating gyroscope) design, in which the rotor is sealed into a cage floated in viscous temperature-controlled oil and an inductance pick-off with a sensitivity of one second of arc derives the output ; a drift rate of 0·05 deg. per hour is claimed.

Contracts

BOULTON AND PAUL, LTD., Norwich, has secured an £80,000 contract from the International Steel Company of Evansville, Indiana, for a mechanised handling plant for the fabrication of structural steel sections. It is stated that the plant will be the first of its kind in the U.S.A. An experimental plant was installed in the Riverside Works of Boulton and Paul in Norwich in 1953. The order for the Evansville Works involves the manufacture of a specially designed plant consisting of a sawing unit and two drilling units linked by automatic conveyor systems. Delivery is scheduled for January, 1959.

MARCONI'S WIRELESS TELEGRAPH COMPANY, LTD., has received from the New Zealand Post Office a further contract for the supply of four multi-channel v.h.f. radio links. The approximate value of the order is £90,000. In all, sixteen terminals, type HM100, fourteen repeaters type HM150, twin-stack Yagi aerial arrays, special aerial securing steelwork, spares and a comprehensive amount of test equipment are to be supplied. Three of the links will be in North Island. One of these is to be between Hamilton and Rotorua, with a repeater station at Taotaoroa. Another, from Palmerston North to Napier, will have repeater stations sited at Gorge, Norsewood and Hollis Road, while the third will be from Himatangi via a repeater at Mount Mataroa to Waiouru. The South Island link will run from Dunedin, via repeaters at Mount Stuart and Gore, to Invercargill. Each link will provide up to forty-eight simultaneous high-grade telephone channels. All the radio equipment will be duplicated, so as to provide a quiescent standby link which would automatically take over the service in the event of a failure on the one normally in use.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., has received an order from the British Post Office to supply the radio equipment for five stations of the new v.h.f. Public Correspondence Maritime Telephone Service, whereby passengers and others on suitably equipped vessels approaching or leaving the shores of this country will be able to call any subscriber on the Post Office telephone system. The first of the new stations, at North Foreland, Kent, is due to come into service in August, for vessels in the Straits of Dover and within 40–50 miles of North Foreland. Additional stations at Niton, I.o.W., Humber and Land's End should be ready for service in the summer of 1959. The site of the fifth station has not yet been determined. Marconi "HX86B" transmitters and "HR86B" receivers will be used at all stations. The equipment will be mounted in special racks, and to simplify monitoring and testing procedure specially designed test gear will be mounted in the same racks. Each station will have two complete radio channels, one of which will be simplex and used exclusively for calling, and in cases of emergency. This will operate on the internationally agreed frequency of 156·8 Mc/s. When contact is established the call will be switched to a duplex working channel, which will operate on one of the internationally agreed channels for public correspondence.

Miscellanea

ROAD RESEARCH LABORATORY.—The Road Research Laboratory will open its Materials and Construction Division at Harmondsworth and its Traffic and Safety Division at Langley to visitors from industry, the universities, local authorities and government departments on May 15 and 16 next.

INSTITUTION OF ENGINEERS-IN-CHARGE.—The fifty-third annual dinner of the Institution of Engineers-in-Charge was held, in London, last Friday evening, the president, Sir Harold Roxbee Cox, being in the chair. The principal guest was Mr. A. H. A. Wynn, scientific member of the National Coal Board. In a speech proposing the toast of "The Institution" Mr. Wynn commented on the present state of the coal mining industry, emphasising in particular that the benefits of the National Coal Board's programme of technical development were now becoming more and more evident.

CRANE DISTRIBUTORS CONFERENCE.—More than sixty of the appointed distributors of Coles cranes from all parts of the world attended an international conference organised by Steels Engineering Products, Ltd., and held at Scarborough last week. The object of the conference was to bring together all those responsible for the sale of Coles self-propelled, truck-mounted and shunting locomotive cranes to discuss common problems and to formulate the sales policy of the new range of cranes recently introduced. During the conference the delegates attended lectures, film shows and discussions and inspected all the cranes being made in the new range.

INSTITUTION OF CHEMICAL ENGINEERS.—At the thirty-sixth annual general meeting of the Institution of Chemical Engineers, held on April 30, Sir H. Beaver was re-elected president, Dr. E. H. T. Hoblyn and Mr. H. P. Weber were re-elected vice-presidents, and the other vice-presidents elected Messrs. W. K. Hutchison and C. E. Spearing. The Moulton Medal for 1957 was presented to W. D. Armstrong, H. H. Rosenbrock and W. L. Wilkinson for their paper "An Investigation of the Transient Response of a Distillation Column, Parts I and II." D. Train received the Junior Moulton Medal for his paper "Transmission of Forces Through a Powder Mass During the Process of Pelleting." After the meeting Sir Hugh Beaver gave his presidential address on "Science and the State."

MECHANICAL HANDLING.—A new colour film entitled "Mechanical Handling in Iron Production," sponsored by the Mechanical Handling Engineers' Association, was shown in London last week. It illustrates the contribution made by mechanical handling to a specific field of work, the production of iron, and many aspects of this work are covered. Walking draglines are shown removing the overburden to uncover the ore seams, followed by mechanical shovels loading the quarried ore into wagons for transport. The quarrying of limestone, and the belt conveyors used to transport it to a ropeway loading station are shown, followed by its carriage by aerial ropeway to a bunker for discharge into railway wagons. Some of the methods and equipment employed in unloading imported ore from ships are illustrated, together with various kinds of handling apparatus used for the reception of material in railway wagons at an inland mill. The film runs for approximately thirty-five minutes and is available on loan in 16mm size.

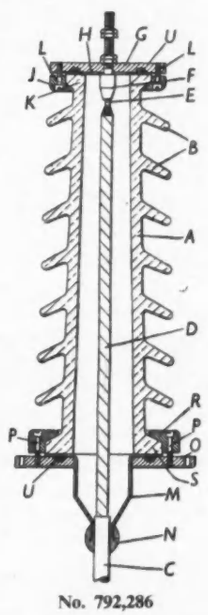
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in Italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

ELECTRICAL ENGINEERING

792,286. July 17, 1956.—POWER CABLE TERMINATIONS, Standard Telephones and Cables, Ltd., Connaught House, 63, Aldwych, London, W.C.2. (*Inventors: Edwin Charles Lee and Ernest John Stickley.*)

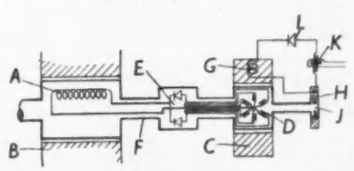
The invention relates to insulated terminations for power cables of which the insulation surrounding the conductor contains oil or gas maintained under pressure. In the drawing there is shown in section a tubular insulator *A* of ceramic material such as porcelain and provided with annular fins *B*. The lead-sheathed power cable *C* is introduced into the tube *A* after the lead sheath has been stripped off a portion of it to uncover the cable core *D*, consisting of the paper-insulated conductor of the cable. At the upper end the paper insulation is stripped off to reveal the conductor *E*. The conductor is conductively attached to a terminal piece *F*, which passes through and is attached to, a metal end plate *G*. This end plate is a phosphor-bronze casting and between it and the ceramic tube *A* there is placed a relatively thin sheet *H* of soft copper. A ring *J*, of phosphor-bronze, engages a shoulder *K* formed in the tubular member and bolts *L* compress the copper sheet *H* on to the open end of the tube. It can be seen that even if the cast end plate *G* is to some extent porous gas or oil included under pressure in the cable insulation will not be able to escape. At the lower end, in the figure, there is provided a gland *M* of relatively thin sheet copper through which the cable *C* passes into the tube *A* and to which it is attached by means of a wiped joint *N*. The ceramic tube is sealed in this case in the same way as in the case of the upper end by means of a phosphor-bronze end plate *O* held in position by bolts *P* engaging a phosphor-bronze ring *R* engaging a shoulder *S* forming part of the ceramic tube. The upper part of the gland *M* is turned over so that it will be compressed between the tube *A* and the plate *O* when the bolts *P* are tightened up. Rubber O rings *U* in the end plates *G* and *O* can be used to prevent any possible leakage of fluid between the sheet copper and the ceramic. This description is made only by way of example and not as a limitation on the scope of the invention.—*March* 26, 1958.



No. 792,286

791,629. August 9, 1955.—EXCITATION ARRANGEMENTS FOR ROTARY DYNAMO-ELECTRIC MACHINES, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. (*Inventor: Erich Siegfried Friedlander.*)

The invention relates to excitation arrangements for rotary dynamo-electric machines having a rotary field winding, such as turbo-alternators. One object is to provide an improved excitation arrangement in which the need for sliprings is eliminated. Referring to the drawing, the rotary field winding *A* of a turbo-alternator *B* is arranged to be fed with exciting current from a six-phase wound exciter alternator *C*, the output of the exciter alternator being derived from its rotor winding *D*, which is connected to the field winding *A* of the turbo-alternator through rectifiers *E* arranged for six-phase rectification. The rotor of the exciter alternator is arranged to be driven together with the rotor *F* of the turbo-alternator and the rectifiers *E* are mounted on the rotor *F* so that the circuit comprising the field winding *A*, rectifiers *E* and the rotor winding *D* rotates as a single unit. The stator winding *G* of the exciter alternator is supplied from a pilot alternator *H*, the rotor *J* of which comprises a permanent magnet and is also driven with the rotor *F*. The output of the pilot alternator *H* is controlled by means of a magnetic amplifier *K*, which is in series with a rectifier *L* and the stator winding *G* of the exciter alternator. Each rectifier is arranged to be cooled by cooling fluid flowing in a closed rectangular path which includes tubes. For efficient operation it is desirable that the cooling fluid shall not have a viscosity greater than that of water, and that its specific heat and coefficient of thermal expansion shall be as high as possible. The cooling fluid may be methyl alcohol, water or a silicone fluid.—*March* 5, 1958.

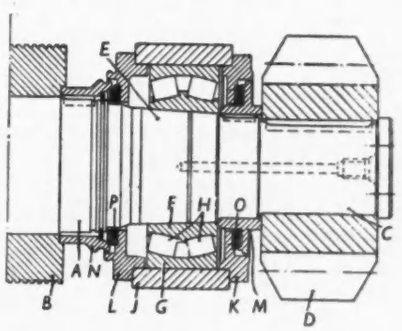


No. 791,629

SUGAR MACHINERY

792,362. April 2, 1954.—ROLLER BEARINGS FOR SUGAR CANE MILLS, Gutehoffnungshütte Sterkrade Aktiengesellschaft, Oberhausen/Rhineland, Germany.

The invention relates to rolls of sugar cane mills supported by bearings of large diameter. The drawing shows the roll *A* and the roll shell *B* mounted on the middle part of a sugar cane mill. Between the middle part and the end journal *C* supporting a coupling cog wheel *D* the roll is supported in a roller bearing in the region of a slightly conical intermediate journal *E*. This roller bearing consists of an inner race *F* directly surrounding the roll journal *E*, an outer race *G* and two rows of barrel-shaped rolling bodies *H* disposed between them. The outer race is contained by a bearing housing *J*. In the axial direction the bearing is closed in by bearing covers *K* and *L* connected to the fixed bearing housing and by labyrinth bushes *M* and *N* revolving with the roll. Movably guided packing rings *O* and *P* are provided. The nominal mean diameter and taper of the conical bore of the inner race *F* are so chosen that when the inner race is forced through a predetermined distance from the point on the journal *E* at which the conical bore, at its larger end, is in complete circumferential contact with the journal, the inner race is expanded and grips the journal with the required force to secure and seat it upon the journal. When the inner race *F* is secured upon the journal the radial clearance between the rollers *H* and the inner and outer races of the bearing must not exceed or fall below a predetermined maximum or minimum limit, respectively. The tolerance limits for the radial clearance are determined in accordance with the required running conditions of the bearing.—*March* 26, 1958.

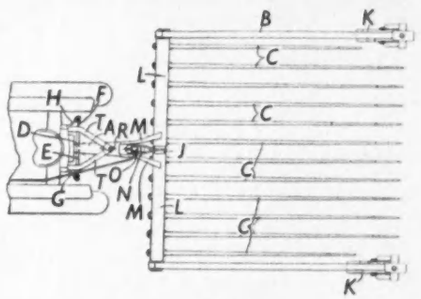


No. 792,362

AGRICULTURAL ENGINEERING

792,925. September 15, 1955.—AGRICULTURAL CROP-HANDLING MACHINES, Blackstone and Co., Ltd., Stamford, Lincolnshire. (*Inventor: William Lawrence Savage.*)

The invention relates to improvements in agricultural crop-handling machines. Its object is to provide a crop-handling machine which combines greater capacity with increased efficiency, avoiding the fouling of the tines in the earth, or failure to pick up the crop. As shown in the drawing, the machine has three main parts, a hitch bar *A*, a wheeled chassis *B*, and an assembly of tine bars *C*. The hitch bar is pivoted at its forward end *D* to a lower connection of cranked rods *E* and *F*, which are pivoted at their upper ends to arms *G* and *H* of the normal three-point suspension at the rear of a tractor. The chassis *B* consists of a tubular front member *J* and a pair of side members fixed to the ends of this tubular member, and each supported at its rear end by a castor wheel *K*. A pair of outer tubular members *L* each carry a number of tine bars and are a sliding fit over the front member *J* of the chassis. They are rigidly fixed to the hitch beam *A* by a pair of brackets *M* constituting a yoke. The outer members *L* are spaced slightly apart from one another at their inner end to expose a short section of the chassis front member *J*. An upwardly extending forked arm *N* is fixed to this exposed part, and is pivotally connected at its outer end to the end of the piston-rod *O* of a hydraulic ram or jack. The cylinder of the ram is pivoted to the after end of the hitch beam *A* and a flexible pipe connects the cylinder to the outlet of an hydraulic pump powered by the tractor engine. The tine bars *C* are considerably longer than those normally used in this type of machine, and their free ends terminate more or less at the line joining the castor wheel standards. A fore and aft slot *R* in the upper surface of the hitch beam *A* is engaged by a vertical pin fixed at the junction of a pair of pivotal arms mounted on the tractor linkage pins. The engagement between slot and pin prevents any yawing of the machine relative to the tractor. In a crop-gathering operation, the tine bars *C* are permitted to float freely above a minimum ground clearance of their free ends controlled by the castor wheels *K*, so that there is no tendency for them to dig into the ground. Owing to their comparatively great length the tine bars are able to pick up considerably more weight of crop, as the tractor is backed, than is the case with conventional machines.—*April* 9, 1958.

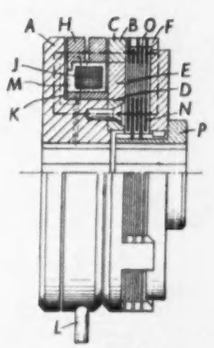


No. 792,925

POWER TRANSMISSION

792,974. September 5, 1956.—SLIPRINGLESS ELECTROMAGNETICALLY ACTUATED COUPLING, Anton Ryba, Via Firenze 40, Bolzano, Italy; Josef Reinisch, Obstmarkt 42, Bolzano, Italy, and Ernst Vinatzer, Obstmarkt 42, Bolzano, Italy.

The invention relates to electro-magnetically actuated couplings, an object of the invention being to provide an improved coupling which affords the advantages of a constant air gap having a minimum width. Referring to the drawing, the coupling comprises as rotary member of the magnet body *L*-shaped part *A* of ferro-magnetic material and a disc shaped part *B*. The latter part is formed of two radially spaced pole rings *C* and *D* and an intermediate ring *E*. The pole rings are made of ferro-magnetic material and the intermediate ring of non-magnetic material. The disc *B* is secured to part *A* of the magnet body by means of screws. The stationary member of the magnet body of the coupling is formed of a ferro-magnetic ring *H*, an exciting coil *J* and a bearing ring *K*. The stationary member of the body is held by suitable means indicated as a pin or bar *L*. Coil *J* is embedded between ferro-magnetic ring *H* and bearing ring *K* in a suitable hardened insulation mass *M*, so that ring, coil and bearing ring constitute a unit. The stationary part of the magnet body is journalled upon the rotary part so that it has a minimum play in radial and axial direction. The coupling components are shown as coupling discs *N* which are secured to carrier lugs *F* by being fitted in slots and inner coupling discs *O*, which are fixed to a coupling sleeve *P*.—*April* 9, 1958.



No. 792,974

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

FLAT DRIVING CHAINS FOR REVOLVING FLAT CARDING ENGINES

No. 2934 : 1957. Price 3s. This new standard has been issued as part of the programme of standards being developed by the B.S.I. Textile Machinery Industry Standards Committee. It deals with the chains for driving revolving flats on the carding engines used in the processing of cotton and staple fibres and specifies basic dimensions of the chains, the material for the links and bushes, and a length test.

LOW DENSITY POLYTHENE ROD

No. 2919 : 1957. Price 3s. This new British Standard has been prepared primarily to meet industry's need for a rod to be used in conjunction with low density polythene tubes (as specified in B.S. 1973) and with low density polythene sheet, for which a standard is now being prepared. The new publication specifies both black and natural polythene rod and provides for two grades with different metal flow indices. Requirements are specified for diameters and tolerances, as well as for physical properties. The standard makes reference to the B.S.I.'s certification mark scheme.

METHODS OF TESTING VULCANISED RUBBER : DETERMINATION OF HARDNESS

No. 903, Part A7 : 1957. Price 4s. This new publication replaces Part 19 of the 1950 issue of B.S. 903. In it the base plate type gauge has now been omitted, and a slight alteration has been made in the relationship between the indentations and the B.S. hardness degrees. The latter alteration was made so that the values might prove acceptable to the International Organisation for Standardisation, and Part A7 is, in fact, technically identical with draft I.S.O. Recommendation No. 148.

Its contents include definitions, a summary and explanatory note relating to the test, requirements for the test piece and the apparatus, and test procedure. The standard points out that most instruments now in use read directly in British Standard and International rubber hardness degrees, but a special table included for use with older type instruments enables British and International hardness to be quickly derived from the "penetration difference."

Launches and Trial Trips

LLANISHEN, oil tanker ; built at the Wallsend yard of Swan, Hunter and Wigham Richardson, Ltd., for E.R.T. Tankers, Ltd. ; length between perpendiculars 635ft, breadth moulded 84ft 3in, depth moulded 46ft 3in, draught loaded 34ft 8½in, deadweight 31,980 tons, service speed 16¼ knots ; thirty cargo oil tanks, one main pump room, four 1160 tons per hour turbo, vertical, centrifugal cargo pumps, three stripping pumps ; two 550kW, 450V, turbo-alternators, one 150kW diesel-driven alternator ; one set of two-cylinder, double reduction geared turbines, 14,500 maximum s.h.p. at 109 propeller r.p.m., steam supplied at 600 lb per square inch and 850 deg. Fah. by two Babcock and Wilcox boilers.—Trial, January 15.

DARTBANK, cargo ship ; built at Belfast by Harland and Wolff, Ltd., for Andrew Weir and Co., Ltd. ; length between perpendiculars 450ft, breadth moulded 62ft 6in, depth moulded to upper deck 38ft 6in, gross tonnage 6460 ; five main cargo holds, one 25-ton, two 10-ton, twelve 5-ton and two 3-ton derricks, electric cargo winches ; three 175kW diesel-driven generators ; one Harland and Wolff, two-stroke single acting, opposed piston engine, six cylinders, 620mm diameter by 1870mm combined stroke, 118 r.p.m.—Trial, January 17.

RIEVAULX, ore carrier ; built by Smith's Dock Company, Ltd., for the North Yorkshire Shipping Company, Ltd. ; length between perpendiculars 480ft, breadth moulded 68ft 9in, depth moulded 36ft 3in, deadweight 15,600 tons on 28ft 10¼in draught, service speed 11¼ knots ; four main holds, wing water ballast tanks, MacGregor hatch covers, electric deck machinery ; three 200kW diesel-driven generators, two 600 tons per hour vertical, centrifugal ballast pumps ; Hawthorn-Doxford opposed piston, diaphragm, two-stroke oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4450 b.h.p. at 115 r.p.m.—Trial, January 17.

WEYBRIDGE, closed shelter deck cargo liner ; built by Barclay, Curle and Co., Ltd., for the Britain Steamship Company, Ltd. ; length between perpendiculars 460ft, breadth moulded 63ft, depth moulded to shelter deck 38ft 6in, draught 27ft 9½in, deadweight 10,375 tons ; six holds, 3-ton, 10-ton and two 20-ton derricks, electric deck machinery ; two 290kW diesel-driven generators, one 300kW gas turbine generating set ; Barclay Curle-Doxford oil engine, six cylinders, 670mm diameter by 2320mm combined stroke.—Trial, January 28.

PROCYON, cargo ship ; built by the Furness Shipbuilding Company, Ltd., for Sociedad Transoceanica Canopus S.A. ; length between perpendiculars 480ft, breadth moulded 66ft, depth moulded to upper deck 42ft 6in, deadweight 16,125 tons, summer draught 31ft 5¼in ; five cargo holds, one 2-ton and twelve 5-ton derricks, electric winches ; three 150kW diesel-driven generators, one 50kW steam-driven generator ; Hawthorn-Doxford single-acting, two-stroke, opposed piston oil engine, five cylinders, 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 115 r.p.m.—Trial, January 29.

BRITISH HONOUR, oil tanker ; built at Belfast by Harland and Wolff, Ltd., for B.P. Tanker Company, Ltd. ; length between perpendiculars 630ft, breadth moulded 85ft 6in, depth moulded 46ft 8in, deadweight 31,560 tons ; thirty oil cargo compartments, one main cargo pump room ; two 600kW, 440V, geared turbo-alternators, one 75kW steam engine-driven alternator ; one set of compound double reduction geared turbines, 14,000 service s.h.p. at 105 propeller r.p.m., two Babcock and Wilcox water-tube boilers supply steam at 600 lb per square inch and 850 deg. Fah.—Trial, January 31.

ALARIC, open shelter deck cargo ship ; built at Govan by Harland and Wolff, Ltd., for Shaw Savill and Albion Company, Ltd. ; length between perpendiculars 440ft, breadth moulded 64ft, depth moulded to shelter deck 39ft, deadweight 9300 tons, service speed 17 knots ; five cargo holds, one 70-ton, one 25-ton, four 10-ton, six 5-ton and six 3-ton derricks, sixteen winches ; four 175kW diesel-driven generators ; Harland and Wolff two cycle, opposed piston oil engine, six cylinders, 750mm diameter by 2000mm combined stroke.—Trial, February 13.

MENESTHEUS, cargo liner ; built by The Caledon Shipbuilding and Engineering Company, Ltd., for Alfred Holt and Co. ; length overall 494ft 8in, breadth moulded 65ft, depth moulded to upper deck 36ft, deadweight 9660 tons on 28ft 10¾in draught, sea speed 16¼ knots ; six cargo holds, one 35-ton, two 15-ton, six 10-ton, and eighteen 5-ton derricks, electric winches ; two 450kW diesel-driven generators ; Harland and Wolff six-cylinder, opposed piston engine, 8500 b.h.p. at 115 r.p.m.—Trial, February 19.

SUNGATE, cargo ship ; built by the Burntisland Shipbuilding Company, Ltd., for The Turnbull Scott Shipping Company, Ltd. ; length between perpendiculars 435ft, breadth moulded 59ft 9in, depth moulded to shelter deck 39ft 3in, deadweight 10,810 tons ; five holds, one 25-ton, six 5-ton and four 10-ton derricks, electric winches ; three 175kW diesel-driven generators ; Hawthorn-Doxford two-cycle, opposed piston oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4400 b.h.p. at 115 r.p.m., heavy oil fuel.—Trial, February.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH COMPUTER SOCIETY

Mon., May 19.—York Hall, Caxton Hall, Westminster, S.W.1, "Four Years of Automatic Office Work," T. R. Thompson, 6.15 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Tues., May 13.—SOUTHERN REGION : St. Ermin's Hotel, Westminster, London, S.W.1, "The High-Duty Combustion Chamber," R. P. Fraser, 10.30 a.m. ; "Coke in Industry," E. Murphy and A. S. Boyle, 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Sun. to Wed., May 11-14.—Grand Hotel, Eastbourne, Summer Meeting. Papers to be delivered at the Winter Gardens, Eastbourne.

INCORPORATED PLANT ENGINEERS

Mon., May 12.—MERSEYSIDE AND N. WALES BRANCH : The Blossoms, Chester, "Heat Exchangers," Mr. Faunbern, 7.15 p.m.

Tues., May 13.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "Selection of Machine Tools for Maintenance Departments," R. G. Clowes, 7.15 p.m.

Wed. to Fri., May 14 *to* 16.—Grand Hotel, Brighton, Eleventh Annual Conference, "The Exploitation of Change."

Wed., May 14.—WESTERN BRANCH : Grand Hotel, Bristol, "The History of Rolls-Royce," C. W. Morton, 7.15 p.m.

Thurs., May 15.—BLACKBURN BRANCH : Golden Lion Hotel, Blackburn, Brains Trust, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues. to Fri., May 13 *to* 16.—Annual Conference at Buxton.

INSTITUTE OF NAVIGATION

Fri., May 16.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Principles of Inertia Navigation Systems," E. W. Anderson, 5.15 p.m.

INSTITUTE OF PHYSICS

Wed., May 14.—STRESS ANALYSIS GROUP : 47, Belgrave Square, London, S.W.1, One-day Meeting on "Contact Stresses," 10 a.m.

Fri., May 16.—NON-DESTRUCTIVE TESTING GROUP : Lecture Room, 47, Belgrave Square, London, S.W.1, "The Characteristics and Design of Ultrasonic Flaw Detector Transducers," D. G. Christie, 6 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., May 13.—Great George Street, Westminster, London, S.W.1, "Volta Bridge," P. A. Scott and G. Roberts, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, May 9.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2. Discussion on "The Teaching of Applied Acoustics," opened by G. Mather, 6 p.m.

Mon., May 12.—LONDON GRADUATE AND STUDENT SECTION : Savoy Place, London, W.C.2, Annual General Meeting, 6.30 p.m.

Wed., May 14.—RADIO AND TELECOMMUNICATION SECTION : Savoy Place, London, W.C.2, "A New Cathode-Ray Tube for Monochrome and Colour Television," D. Gabor, P. R. Stuart and P. G. Kalman, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION : Visit to Mullard Radio Valve Company, Ltd., Mitcham Junction, Surrey, 2.30 p.m. ★ SHEFFIELD SUB-CENTRE : Grand Hotel, Sheffield, Annual General Meeting ; Films, 6.30 p.m. ★ SOUTH MIDLAND GRADUATE AND STUDENT SECTION : Lecture Hall, College of Technology, Gosta Green, Birmingham, Annual General Meeting, 6.30 p.m.

Thurs., May 15.—LONDON BRANCH : Savoy Place, London, W.C.2, Annual General Meeting ; "Recent Developments in Electronics in the United States," D. G. Fink, 5.30 p.m.

Sat., May 17.—SOUTH MIDLAND EDUCATION DISCUSSION CIRCLE : Visit to the General Electric Company, Ltd., Witton, Birmingham, 10.30 a.m. ; ★ SOUTH MIDLAND CENTRE : Visit to B.B.C. Television Transmitting Station, Sutton Coldfield, and Television Studios, Gosta Green, Birmingham 2.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Wed., May 14.—SOUTHERN GRADUATES' SECTION : Afternoon visit to the Royal Aircraft Establishment, Farnborough. ★ SOUTHERN BRANCH : Visit to the Kent Oil Refinery, Isle of Grain, 10.15 a.m. ★ SOUTHERN BRANCH : Visit to Transport Equipment (Thornycroft), Ltd., Worting Road, Basingstoke, 2 p.m.

Thurs., May 15.—SCOTTISH BRANCH : Visit to Alexander Stephen and Sons, Ltd., Engineers and Shipbuilders, Linthouse, 7 p.m.

Mon., May 19.—MIDLAND GRADUATES' SECTION : James Watt Memorial Institute, Birmingham, Annual General Meeting, Film, "Engineering at Calder Hall," 6.45 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., May 15.—Geological Society, Burlington House, Piccadilly, London, W.1, Annual General Meeting ; Presidential Address, "Productivity," J. B. Dennison.

INSTITUTION OF PUBLIC HEALTH ENGINEERS

Thurs., May 15.—Caxton Hall, Westminster, London, S.W.1, "Discharge of Sewage and Industrial Wastes to Estuaries," B. A. Southgate, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Fri., May 16.—SHEFFIELD AND DISTRICT SECTION : Royal Victoria Hotel, Sheffield, Repeat of the Presidential Address, "The Origin and Function of R.E.M.E.," W. A. Lord, 7.30 p.m.

NEWCOMEN SOCIETY

Wed., May 14.—Lecture Theatre, Science Museum, South Kensington, London, S.W.7, Third Dickinson Biennial Memorial Lecture : "Sixty Glorious Years: The Impact of Engineering on Society in the Reign of Queen Victoria," S. B. Hamilton, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., May 15.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, 46th Wilbur Wright Memorial Lecture, "Automatic Flight—the British Story," G. W. H. Gardner, 6 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN

Wed., May 14.—21, Albemarle Street, London, W.1, "The Royal Institution and the Teaching of Science in the Nineteenth Century," E. Ironmonger, 9 p.m.

ROYAL METEOROLOGICAL SOCIETY

Tues., May 13.—Agricultural House, Knightsbridge, London, S.W.1, Joint Meeting with the National Society for Clean Air, "Progress in Atmospheric Pollution Research," C. J. Regan ; "The Introduction of Smoke Control Areas," W. C. Turner ; "Climatological Aspects of Air Pollution," R. G. Veryard and "Radioactivity in the Atmosphere—Its Origin and Measurement," N. G. Stewart, 4.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Thurs., May 15.—Visit to the Forest Products Research Laboratory, Princes Risborough, Aylesbury, Bucks, arriving at 11 a.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., May 15.—Institute Buildings, Park Place, Cardiff, "Staple Pit Bunkerage versus other Types of Bunkerage," G. Blackmore, 6 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., May 16.—39, Elmbank Crescent, Glasgow, All-day Conference on "Metallurgical and Engineering Aspects of Weight-Saving in Steel Structures," 10 a.m.

Advanced Engineering Courses

Production Planning and Control. UNIVERSITY OF BIRMINGHAM, INSTITUTE FOR ENGINEERING PRODUCTION, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course, 9.30 a.m. Monday, May 12, to 4 p.m. ; Friday, May 23. Fee fifty guineas.

Standard Reactor School Course. HARWELL REACTOR SCHOOL, ATOMIC ENERGY RESEARCH ESTABLISHMENT, Harwell, Berkshire. The first six weeks of the course, commencing September 1, will be held jointly at Birmingham, Bradford and Salford Colleges of Advanced Technology, the remaining part of the course, commencing October 15, will be at Harwell Reactor School. The course finishes on December 23. Fee £250.

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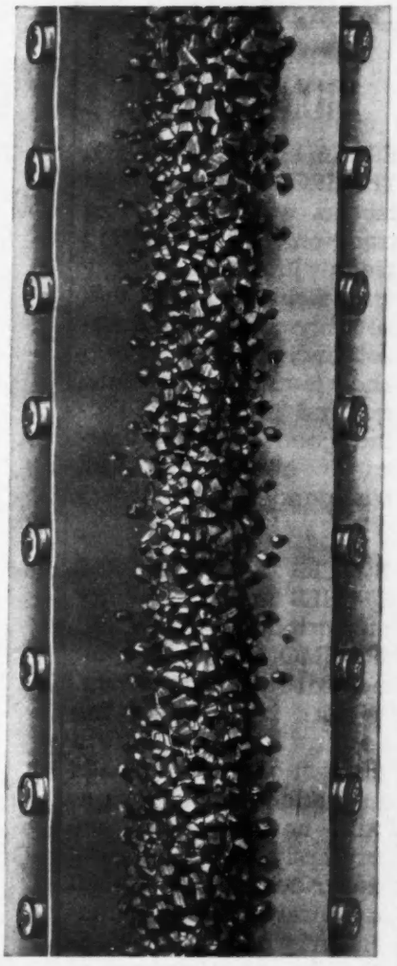

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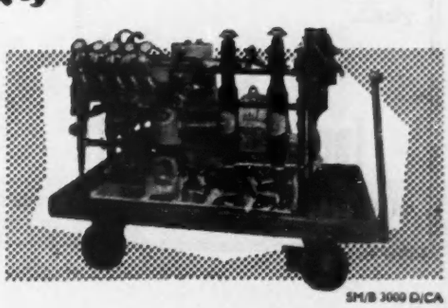

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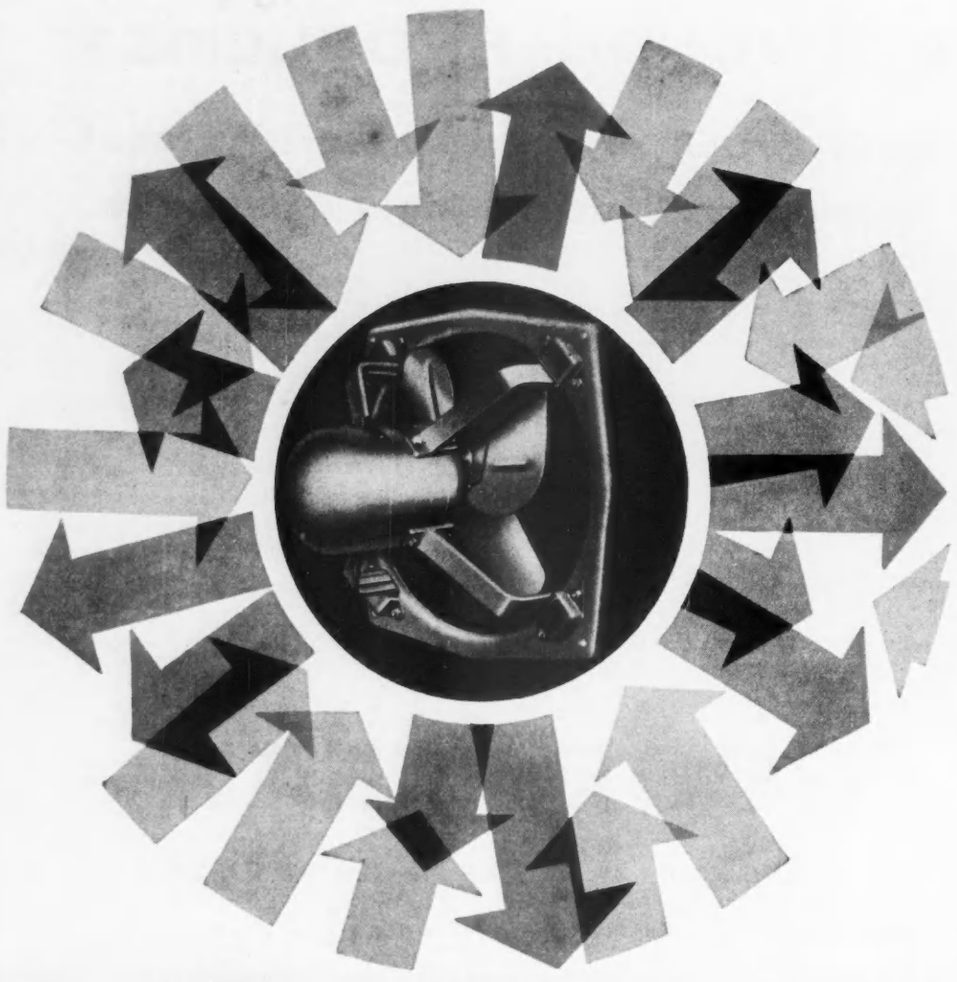

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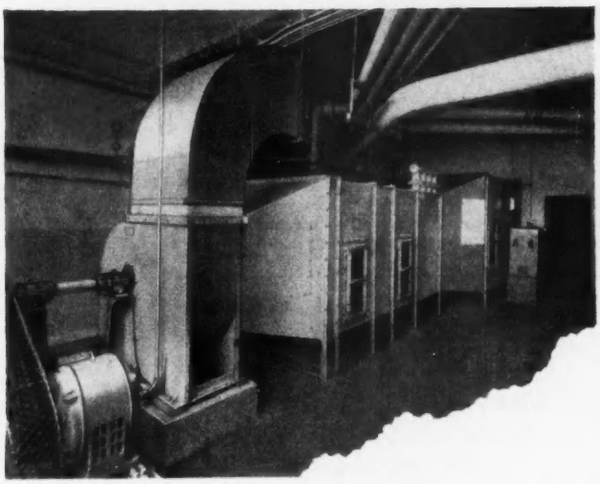

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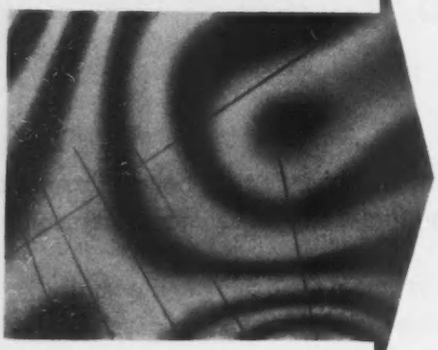

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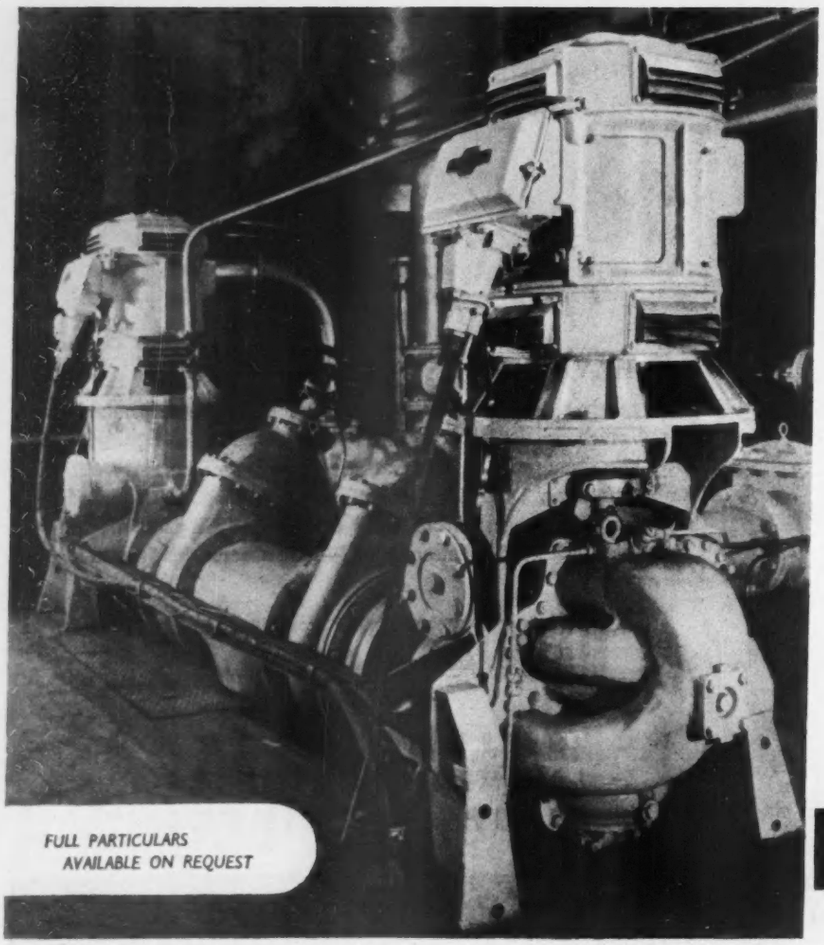

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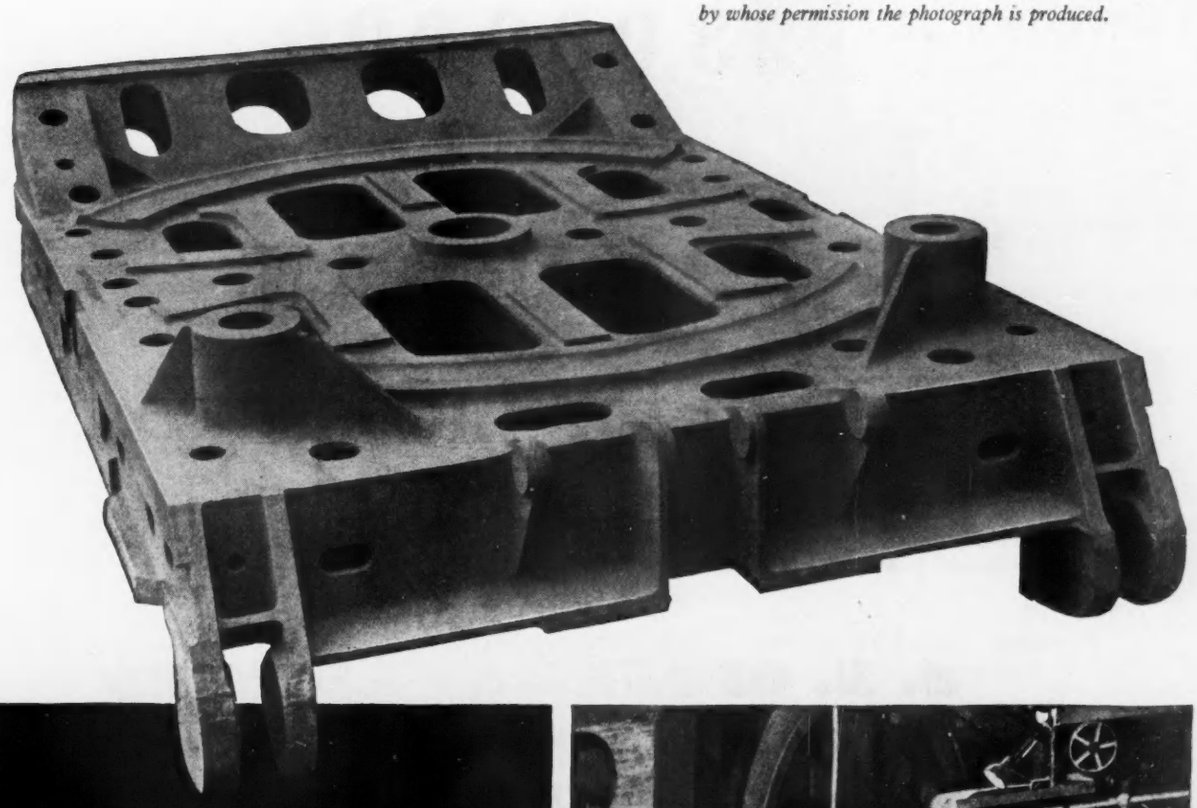
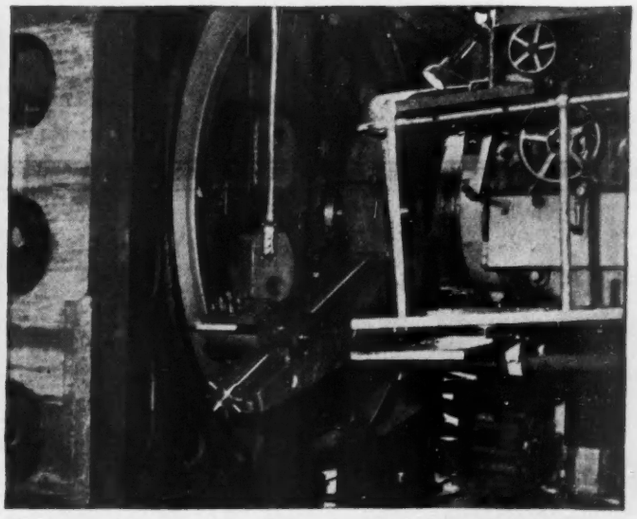
Revolving frame steel casting for the 150-RB excavator, size 10 ft. x 15ft. 6 ins. Cast for Ruston-Bucyrus Ltd. by whose permission the photograph is produced.



cast and machined for an important part



This massive revolving frame is cast in steel for the 150-RB excavator. Weighing 29 tons "as cast" it measures 10 ft. x 15 ft. 6 ins. and is a normal Lloyd production casting. It has to stand up to the severe shock loadings which are developed progressively, as when the 150-RB bites into compacted soil or loose rock that is lifted in one operation. The mould contained 80 cores and there were 21 feed heads. Co-ordinated with the casting was the machining process, a task well within the scope of Lloyds unsurpassed machine shops. The proof of a perfect casting lies in the machining, and it always operates to the advantage of the customer to allow Lloyds to machine the castings they make for him.

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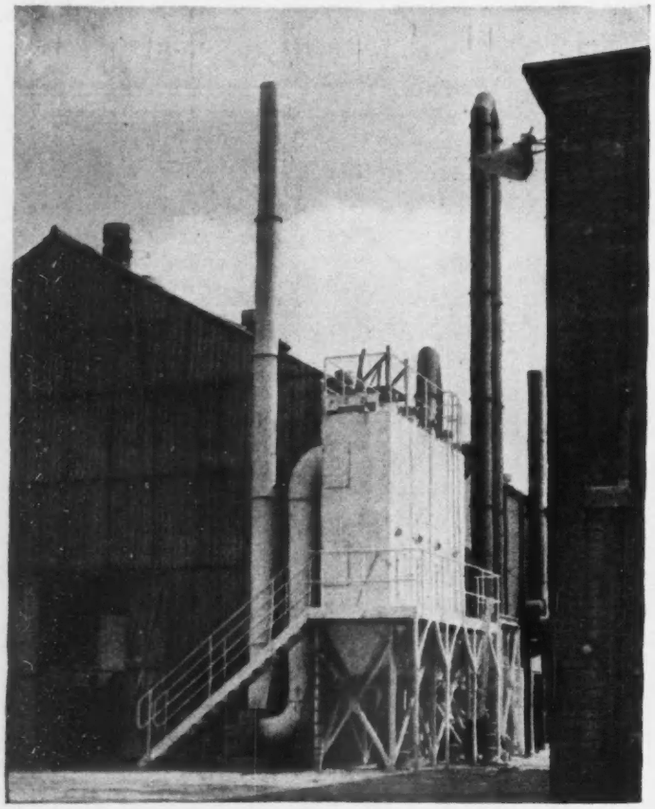

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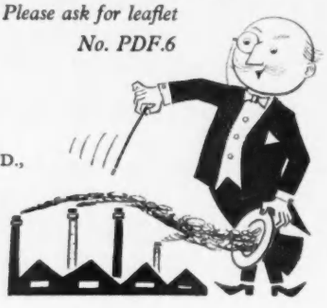

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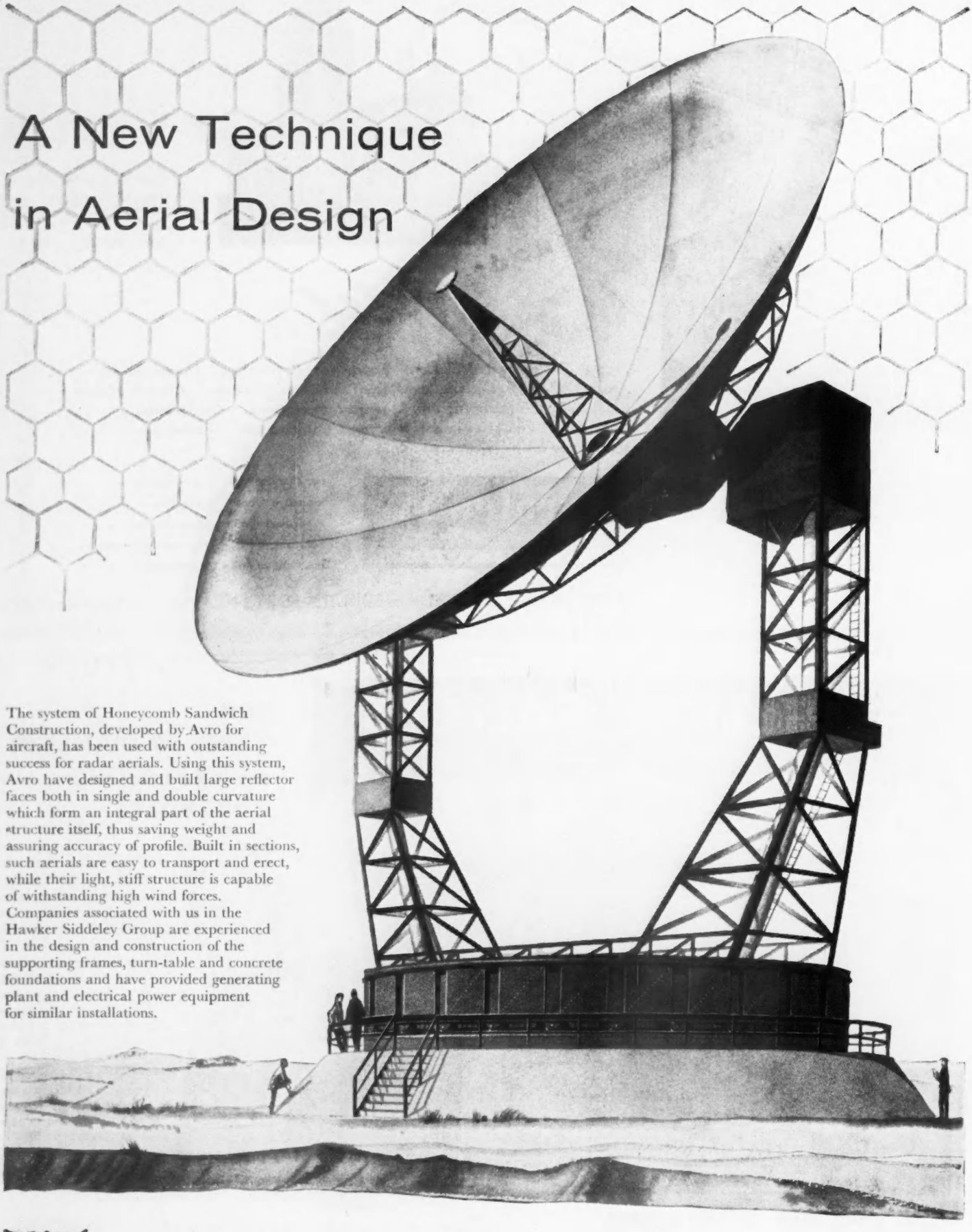

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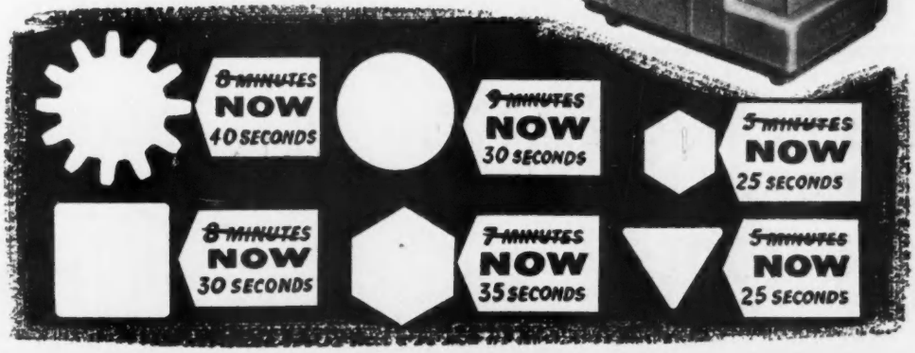
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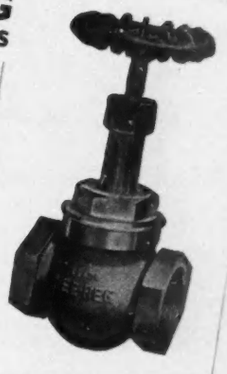

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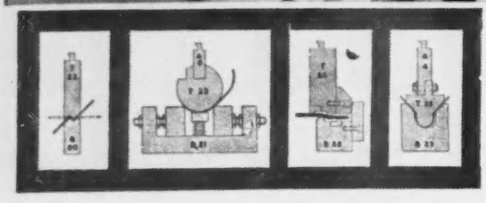

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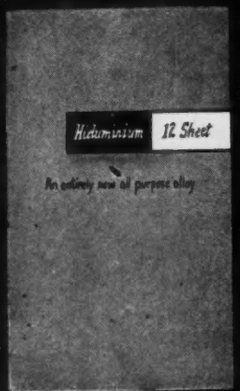

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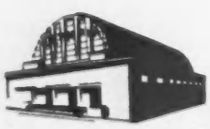

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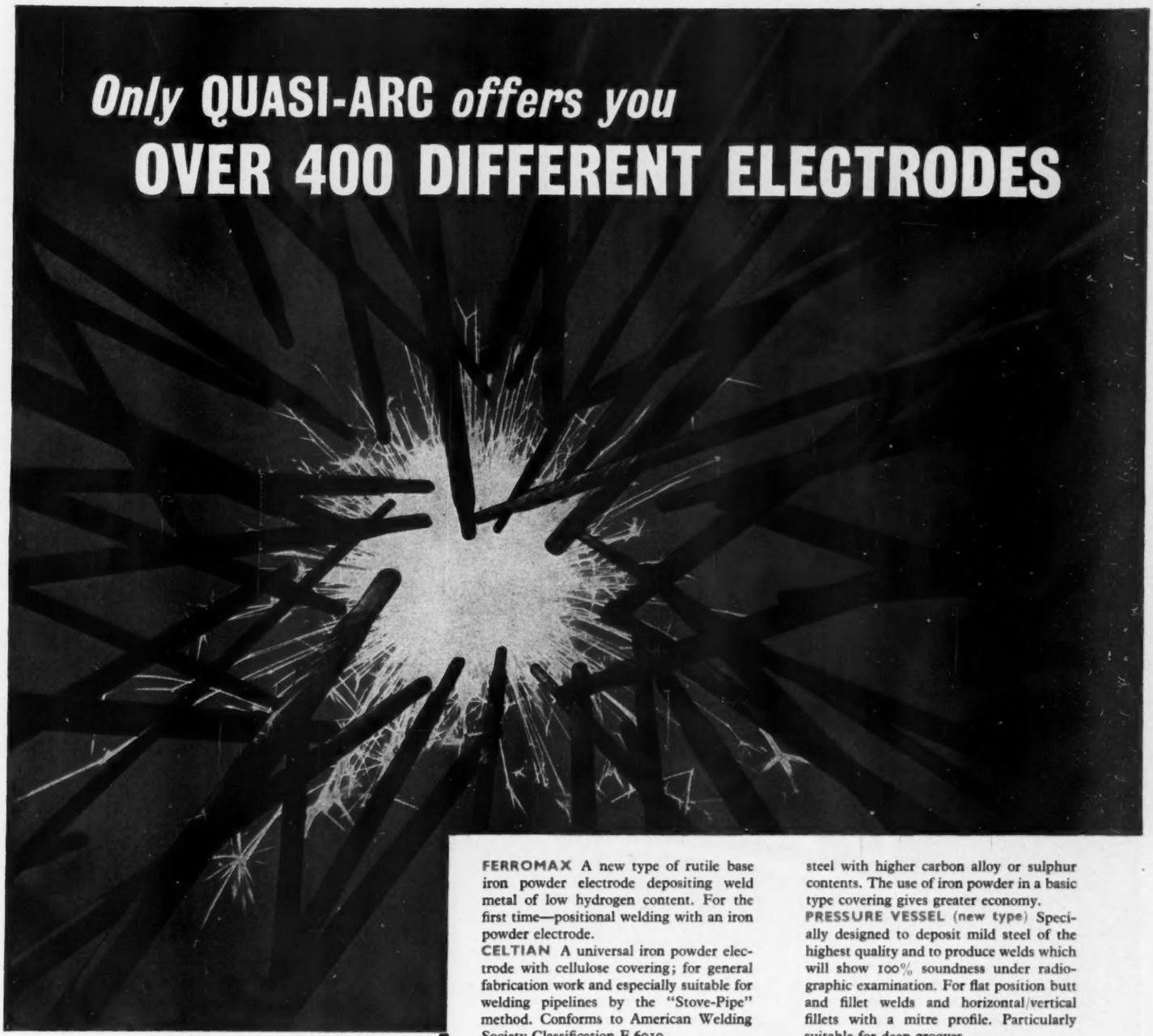

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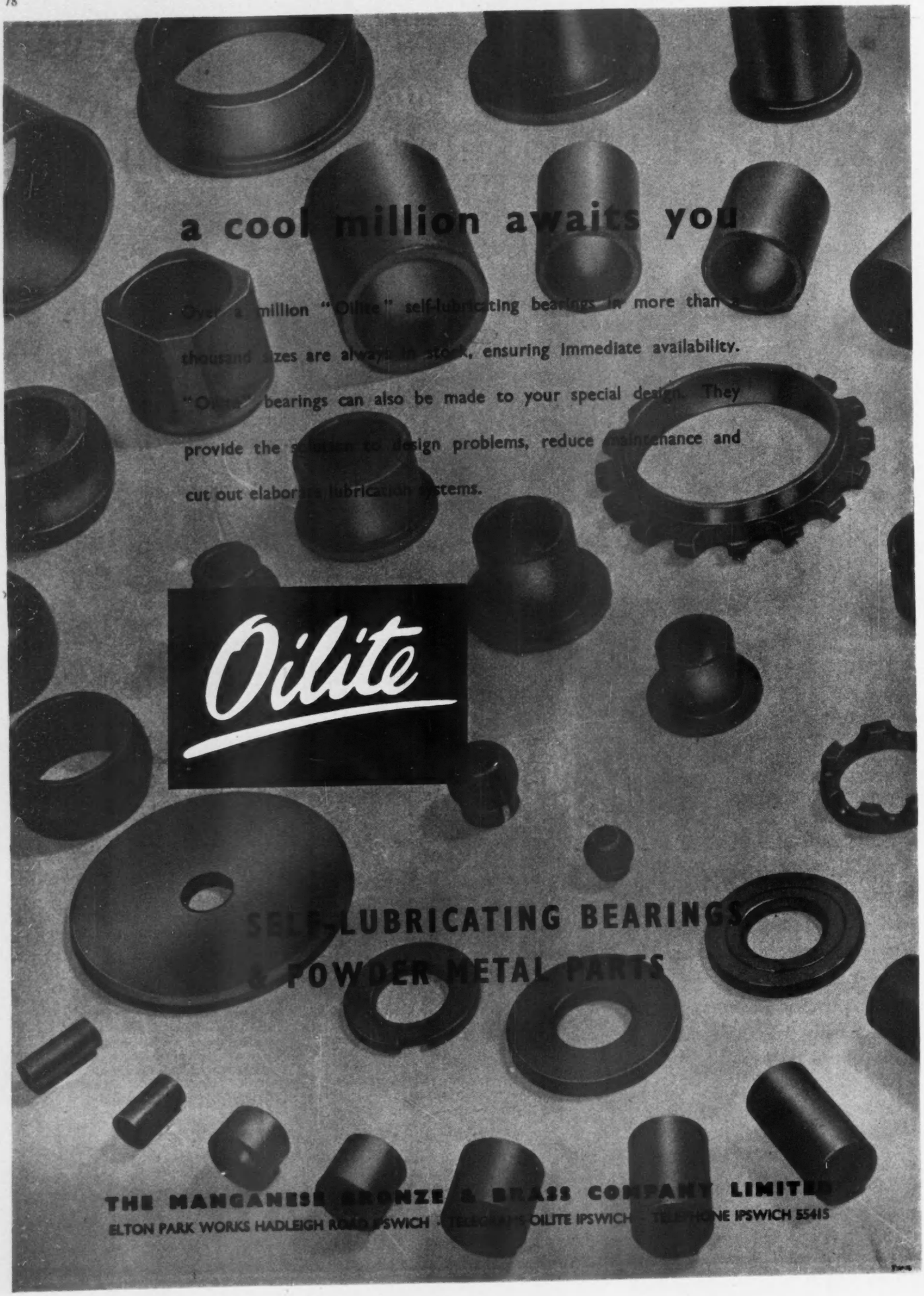
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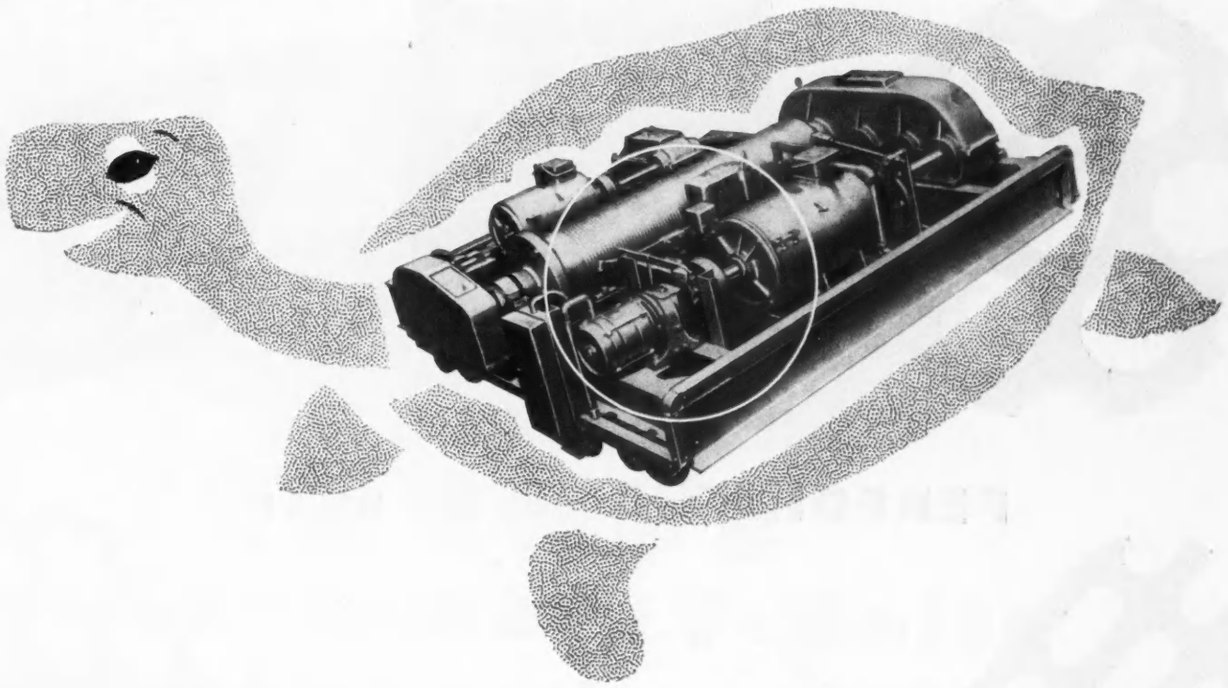

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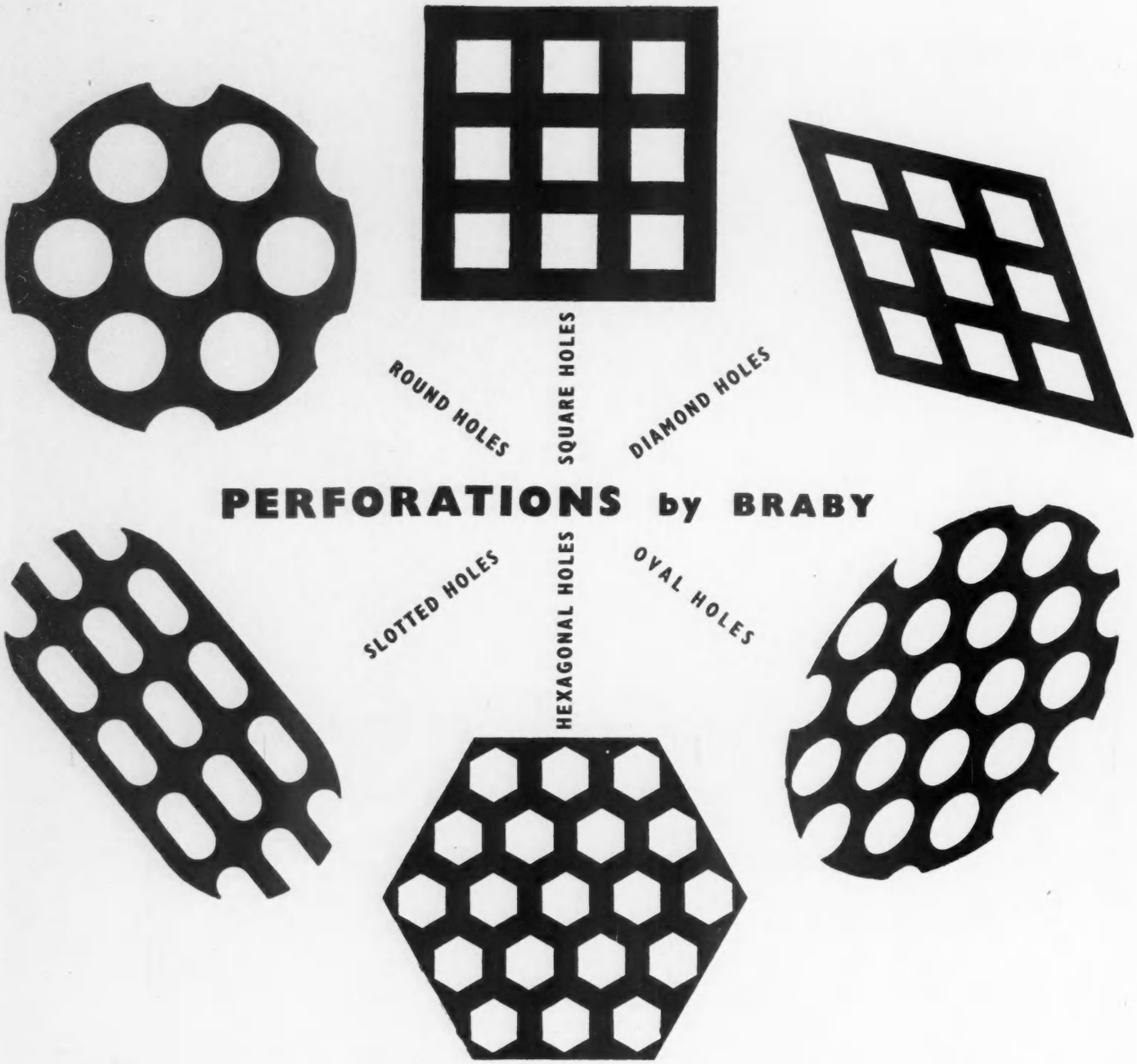

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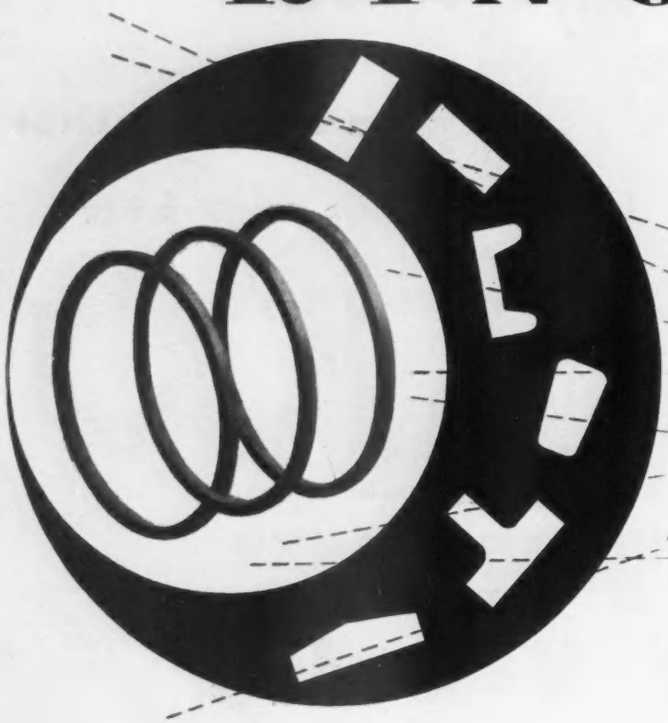

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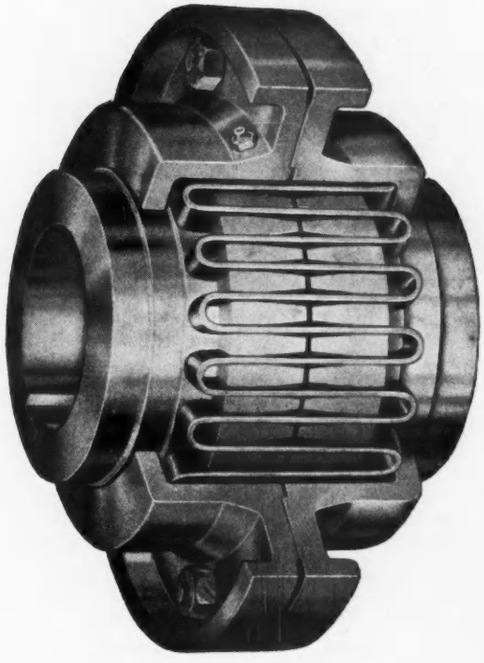

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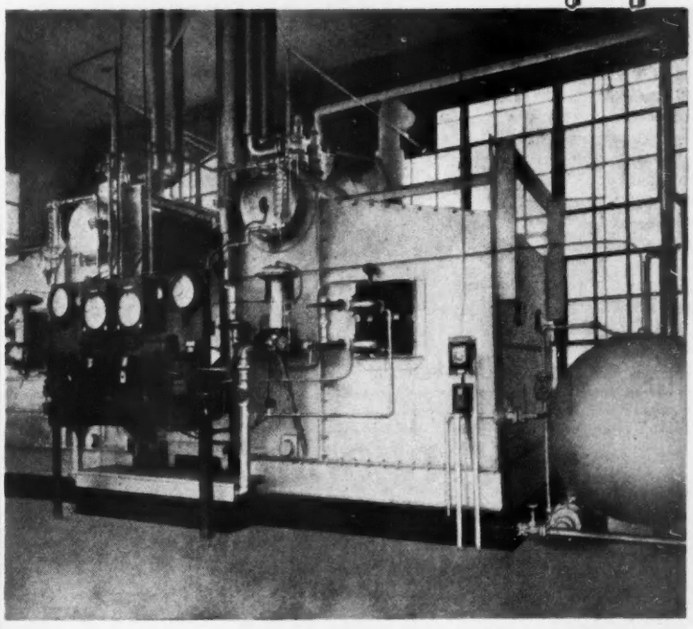

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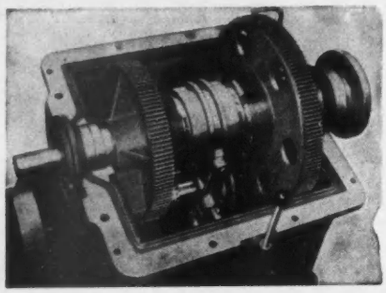

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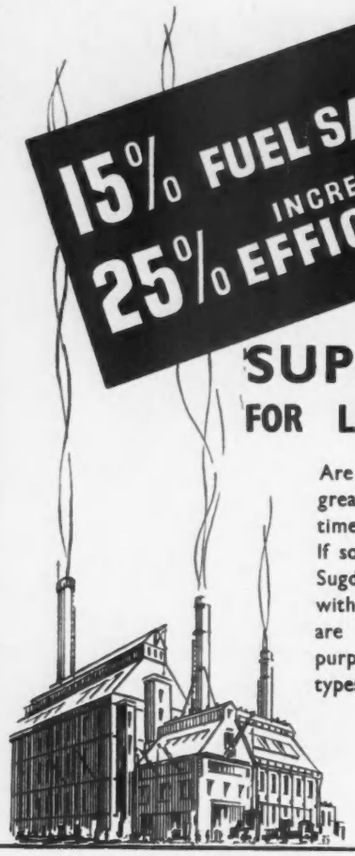

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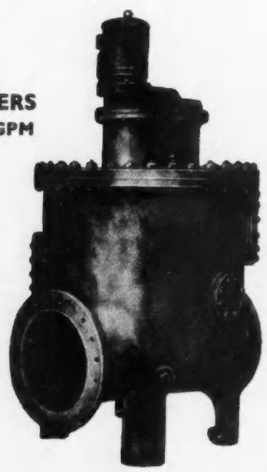

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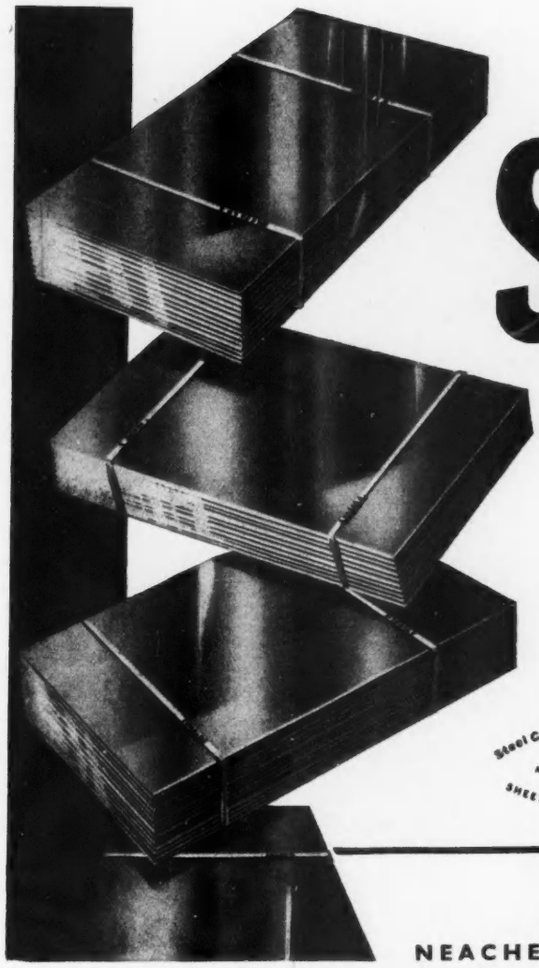

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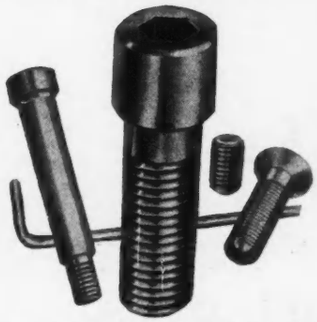

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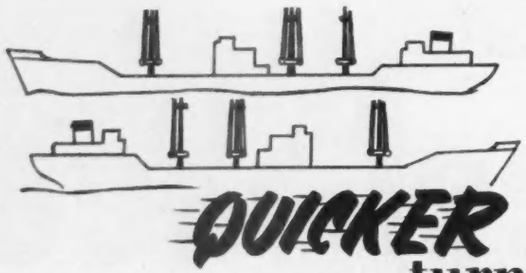

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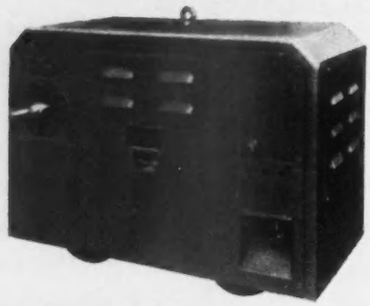

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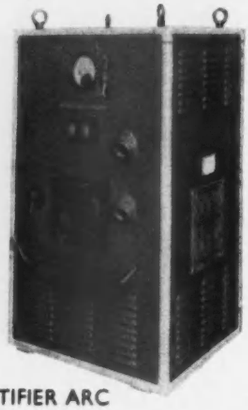

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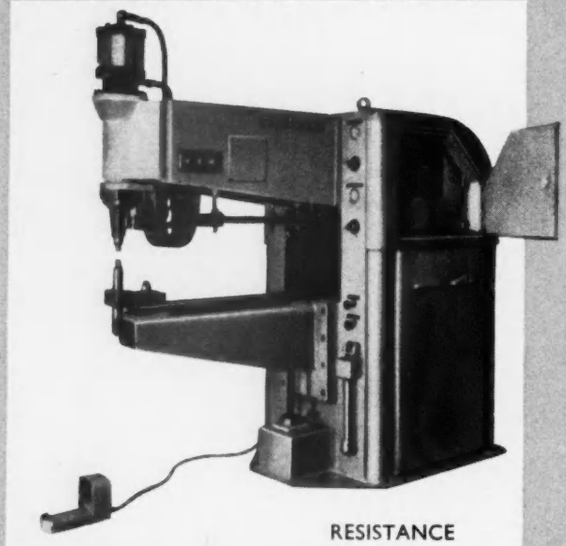

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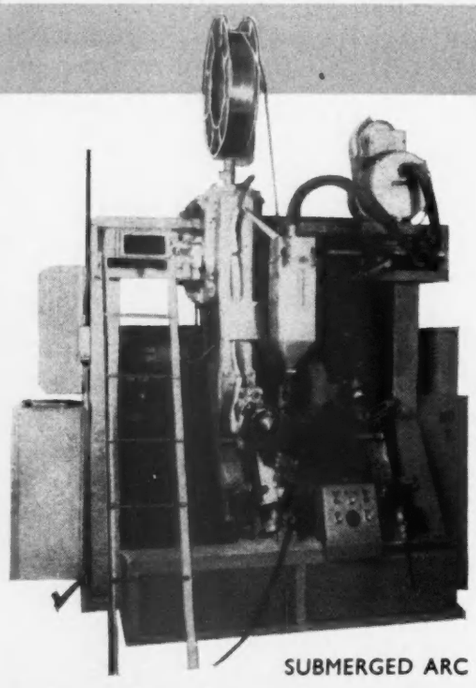

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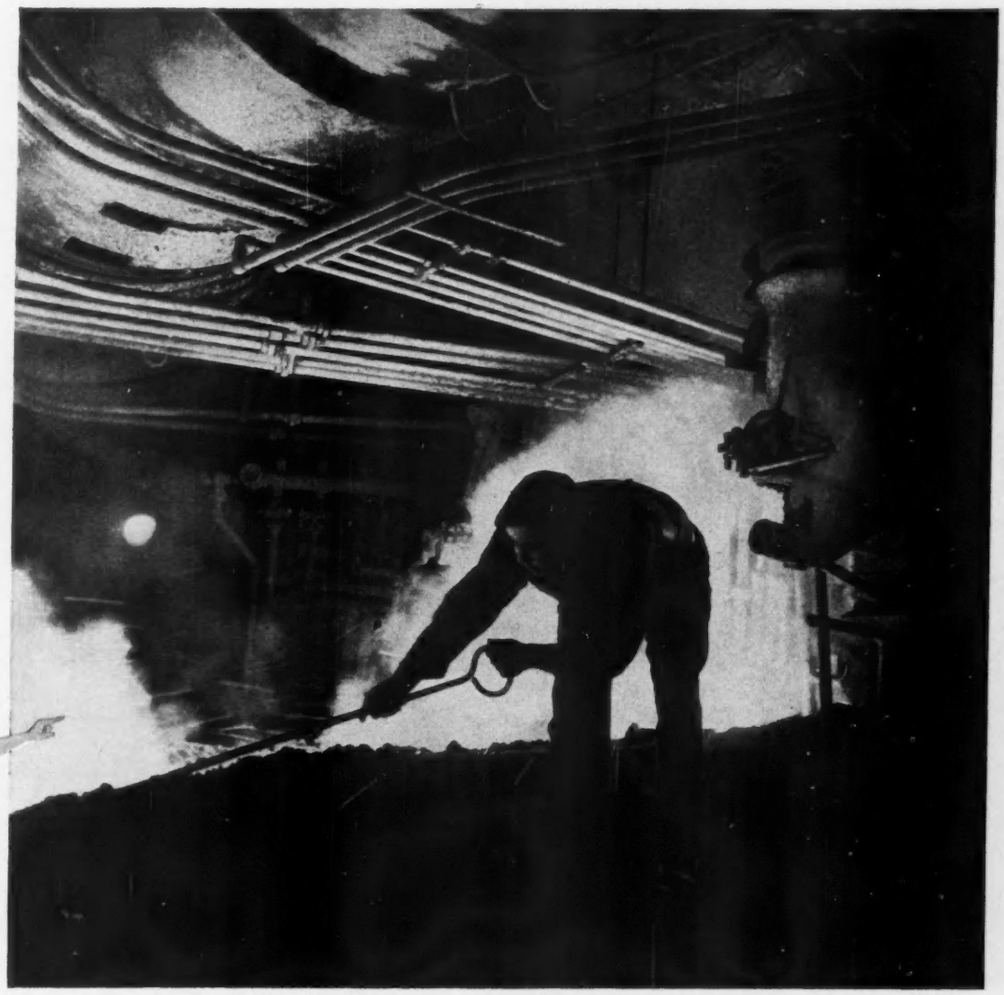

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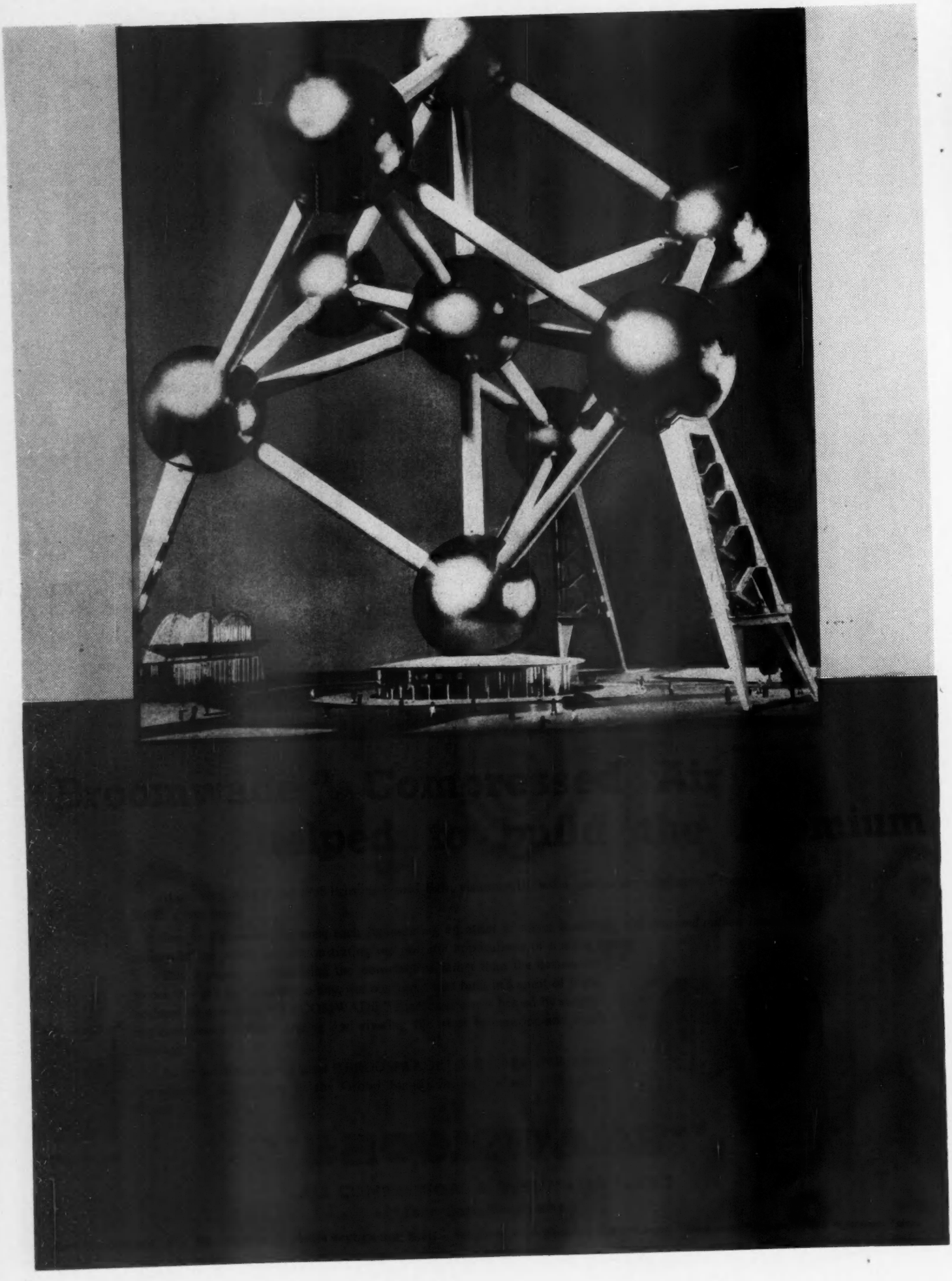

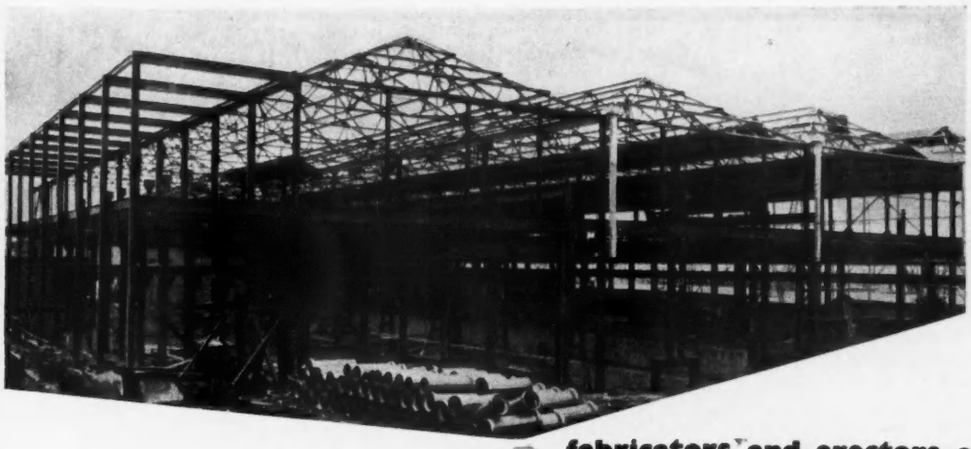

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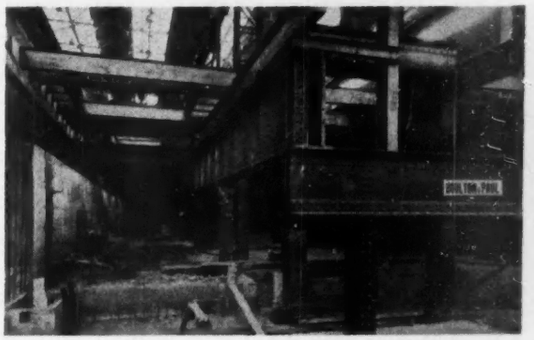

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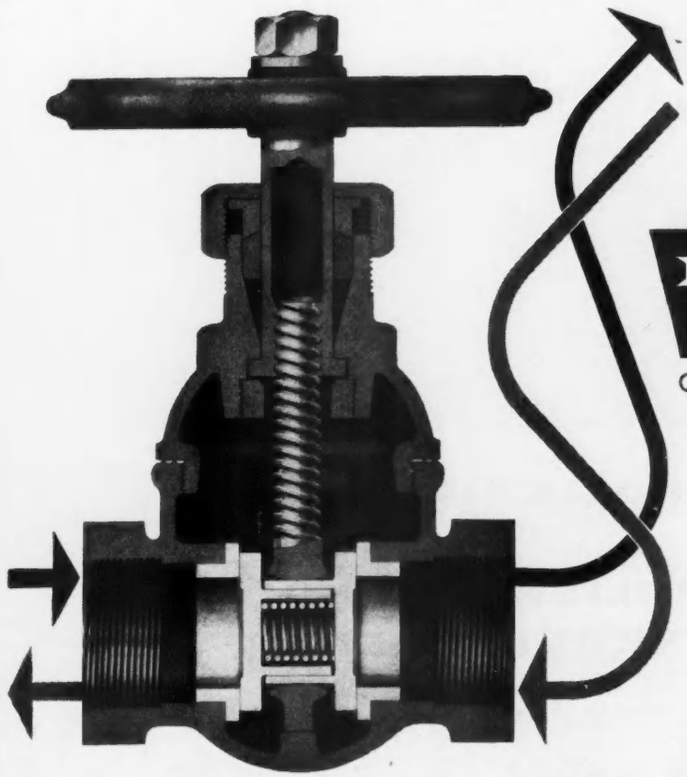

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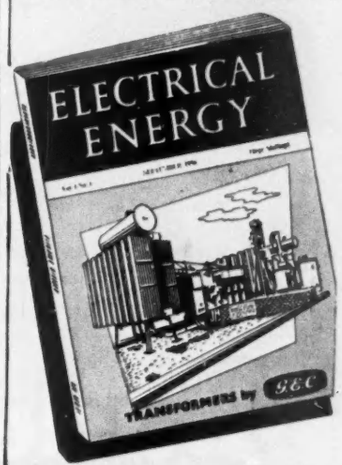

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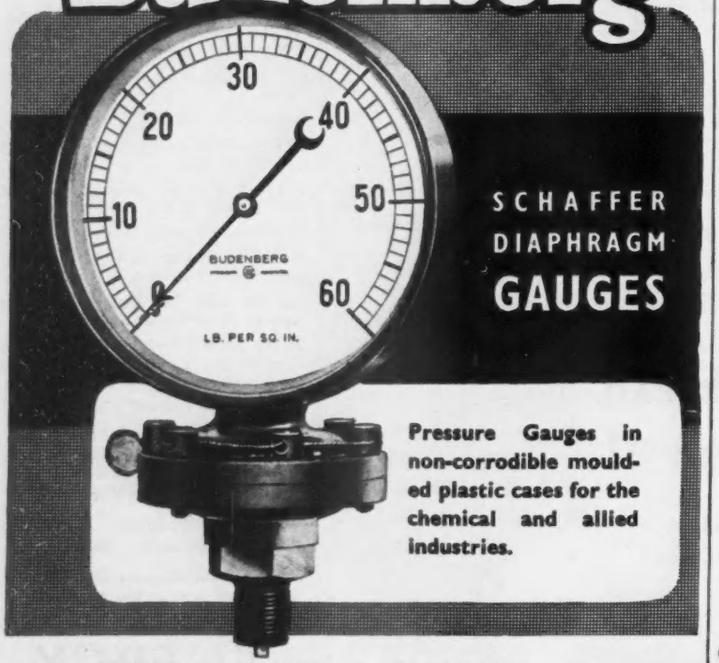

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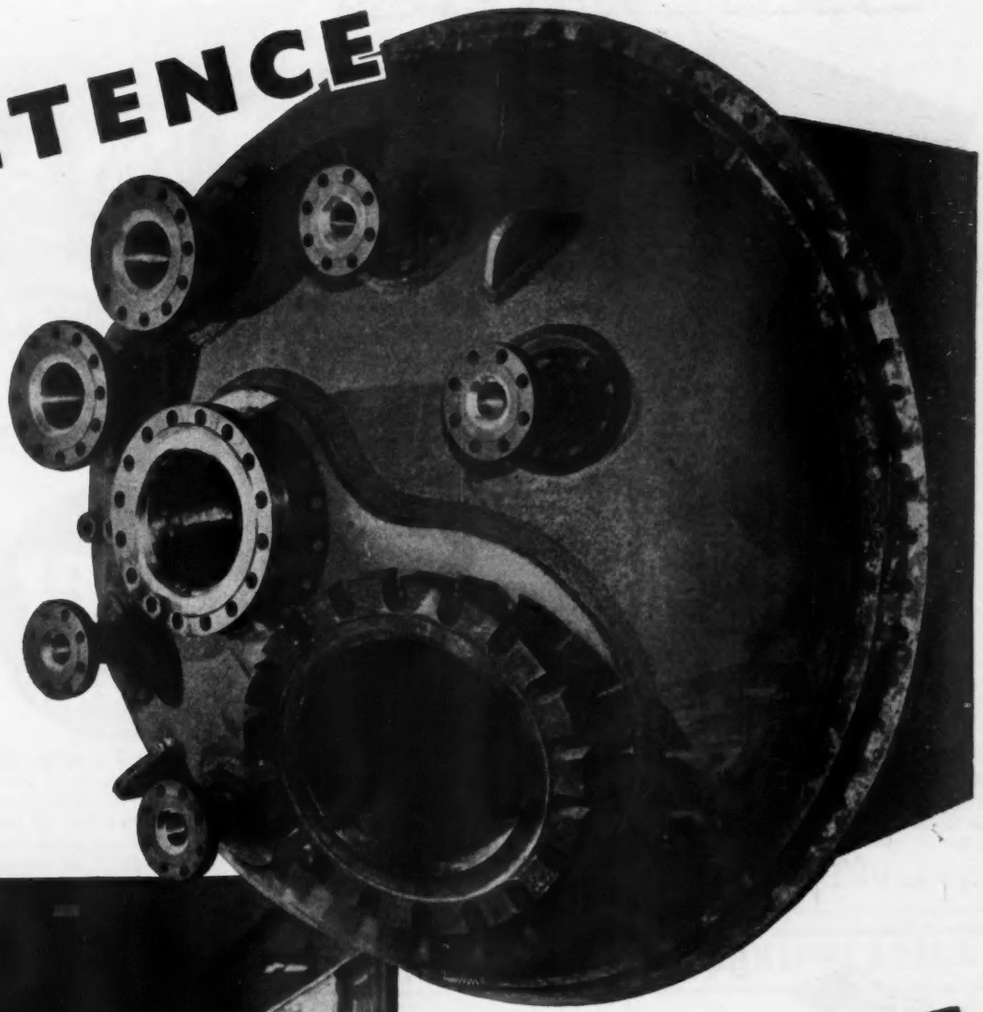

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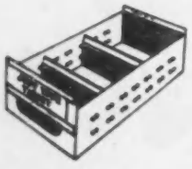

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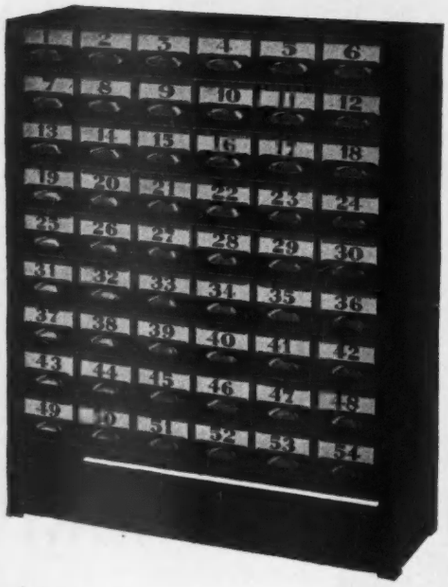

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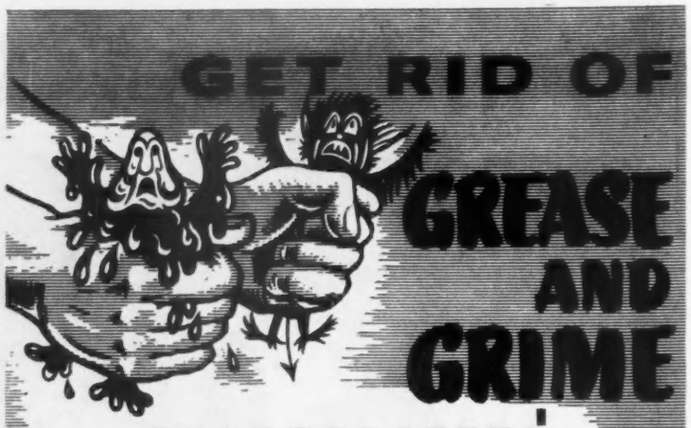

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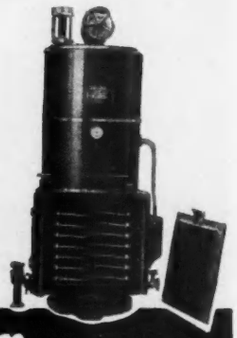

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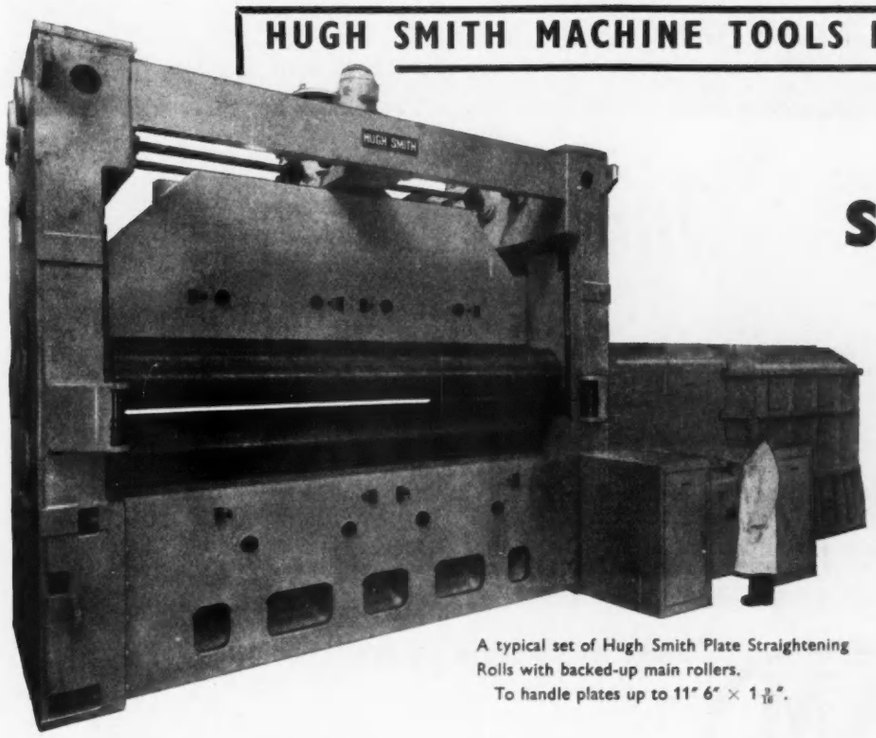

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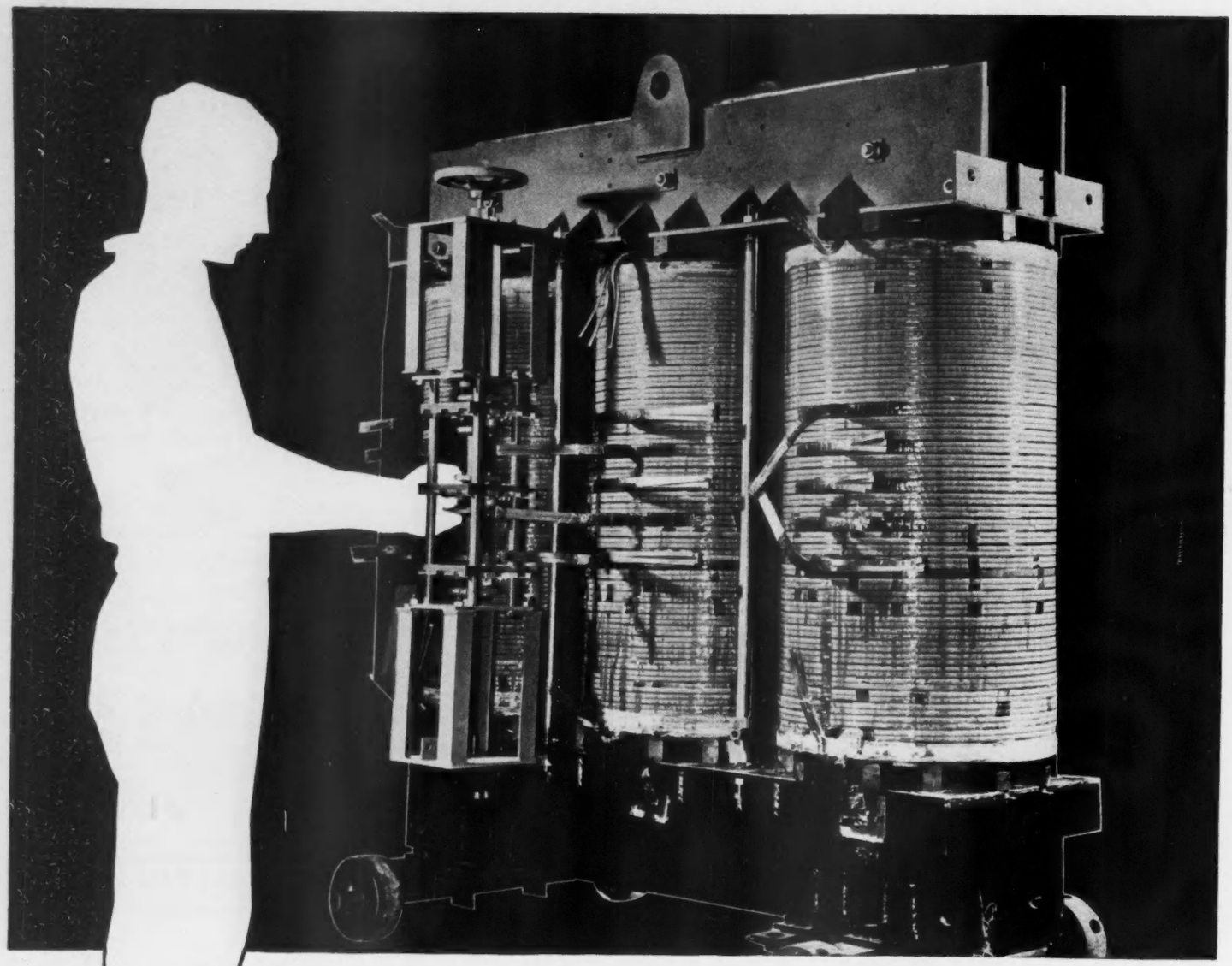

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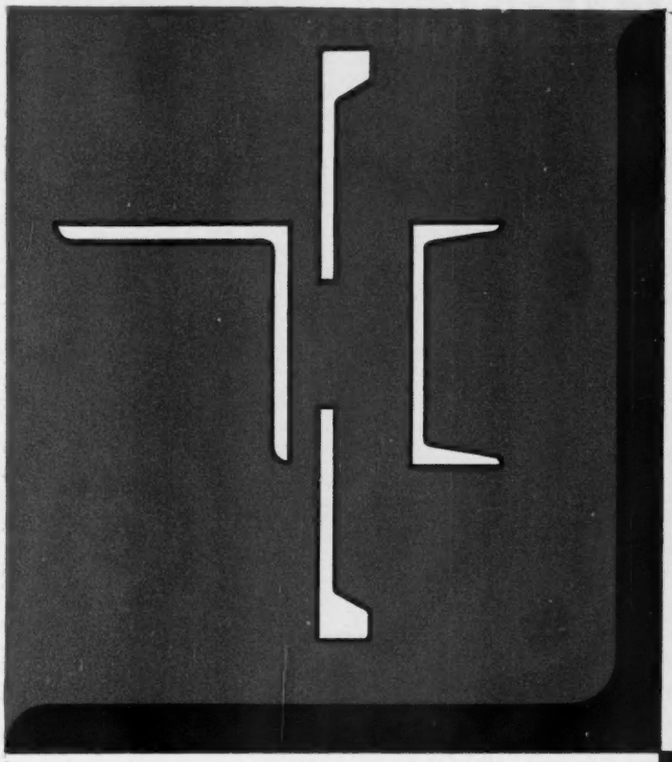

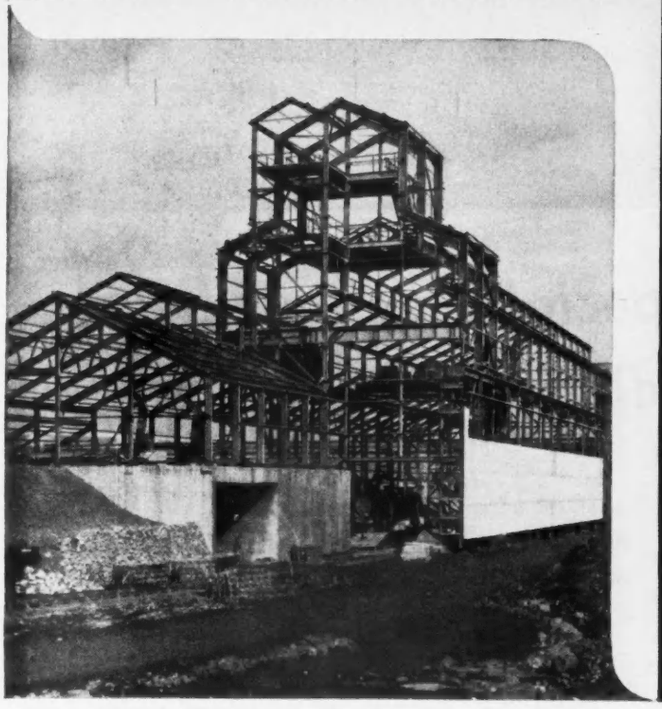

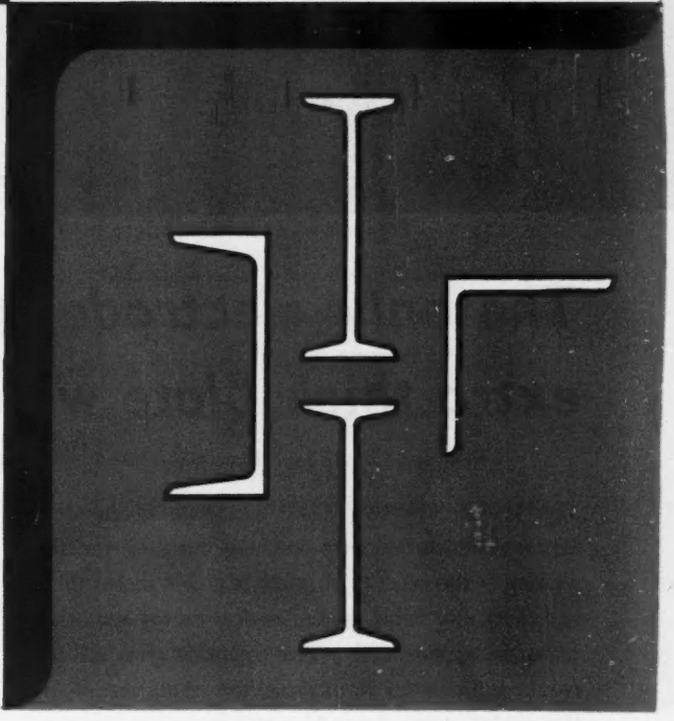

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The framework of the building (left) was constructed to a large extent from Appleby-Frodingham sections and plates. (right) M.S. "Bergensfjord" built for Den Norske Amerikalinje A/S of Oslo has a gross weight of 18,750 tons. Considerable quantities of Appleby-Frodingham plates and sections were supplied to Swan, Hunter, & Wigham Richardson Limited, the builders of this ship.

APPLEBY FRODINGHAM STEEL COMPANY

A Branch of The United Steel Companies Limited SCUNTHORPE LINCOLNSHIRE

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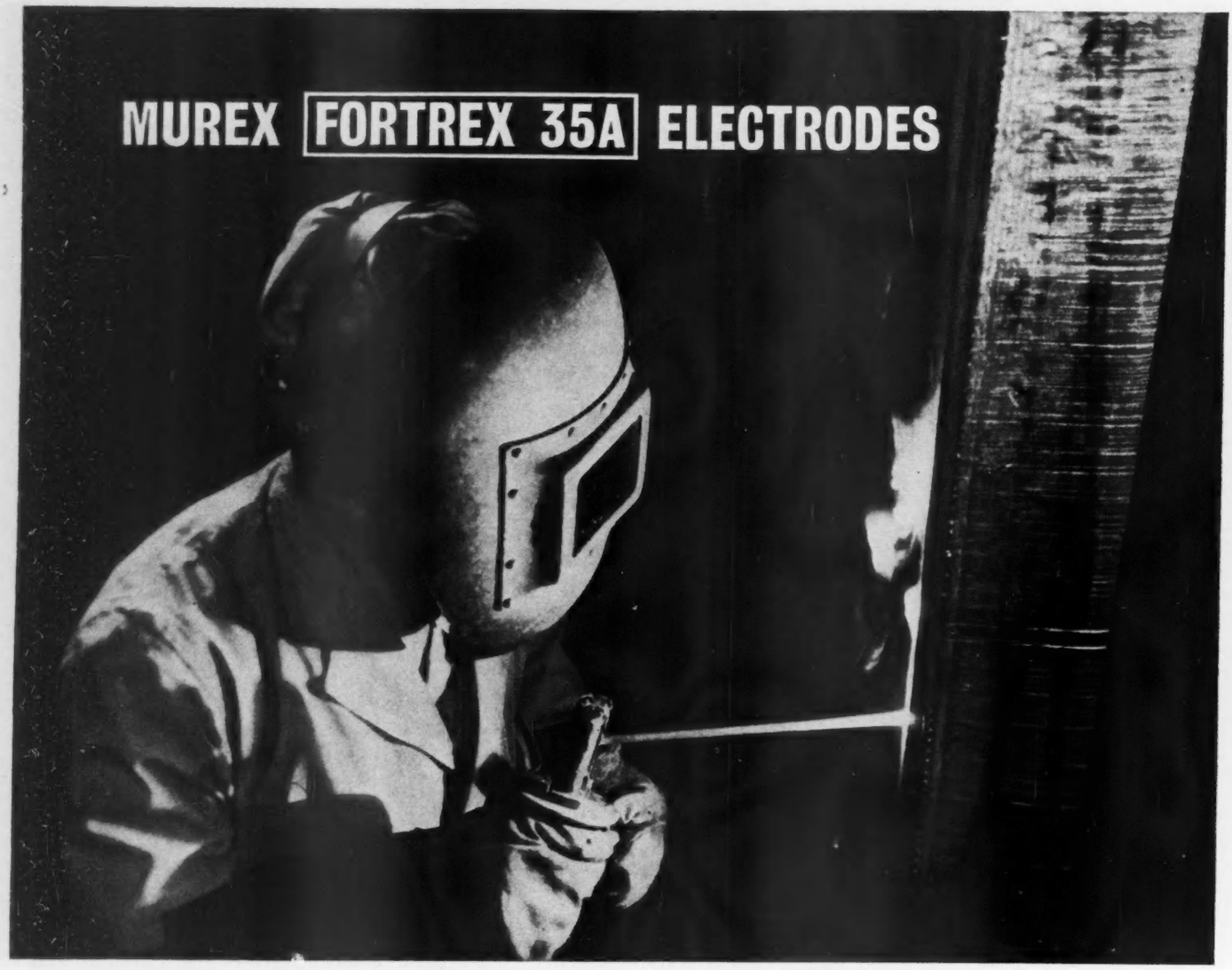

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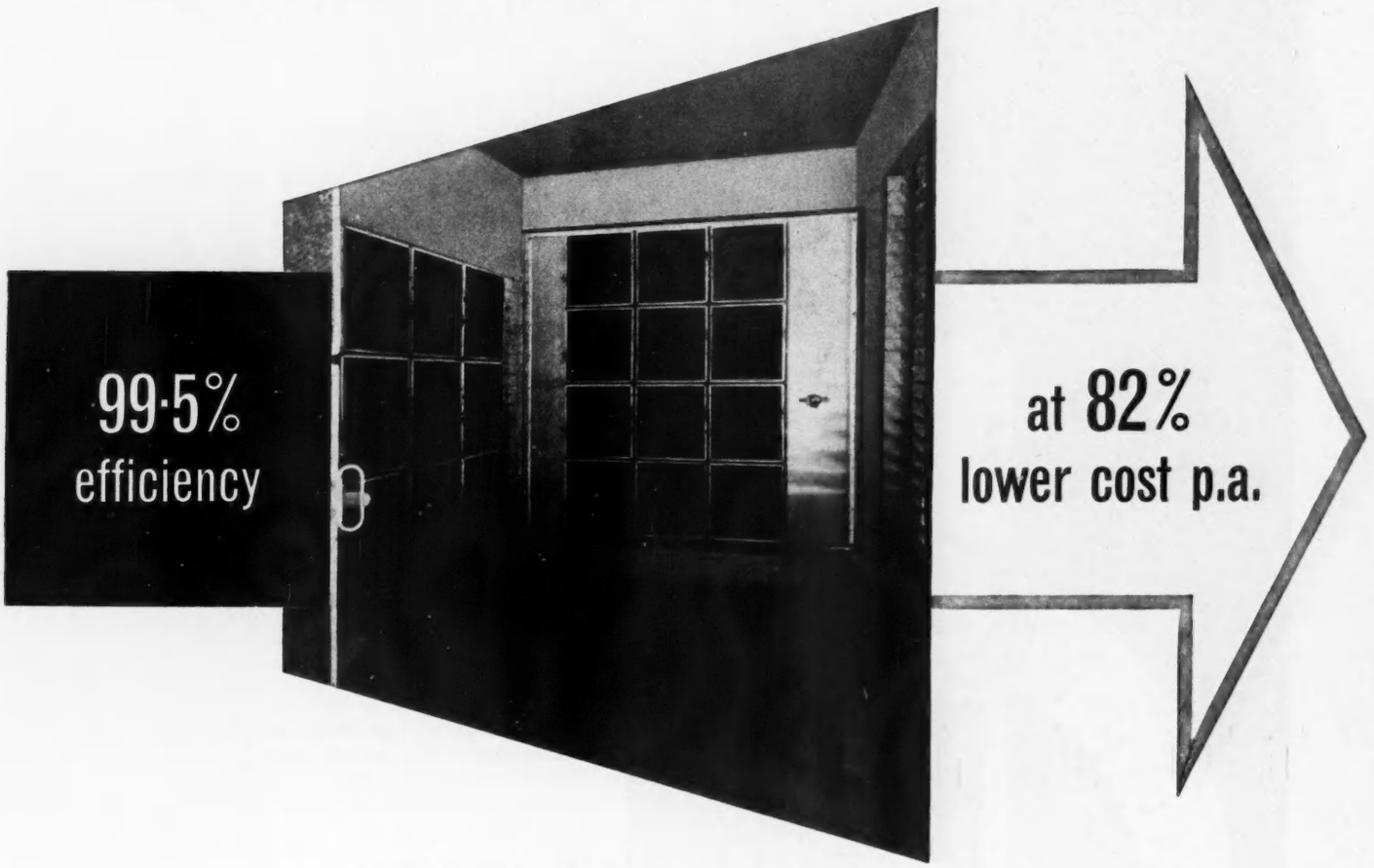

The original filters, which needed changing at 4-week intervals, allowed industrial fly-ash and smuts to get through.

The present FAR-AIR filters, which replaced them, are changed and "laundered" at 8-week intervals, while they are still within their dirt-collecting capacity. A FAR-AIR filter is changed in 15 seconds: each of the previous filters took 20 minutes to change.

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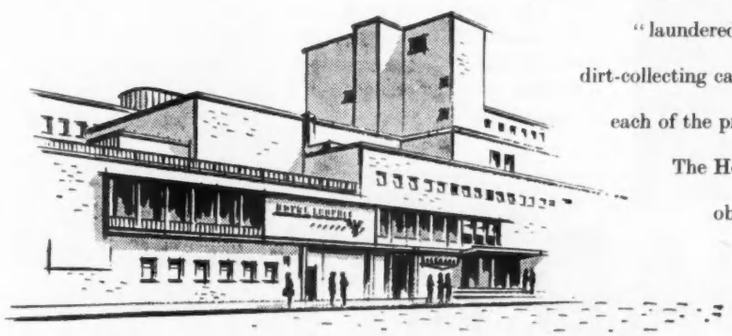

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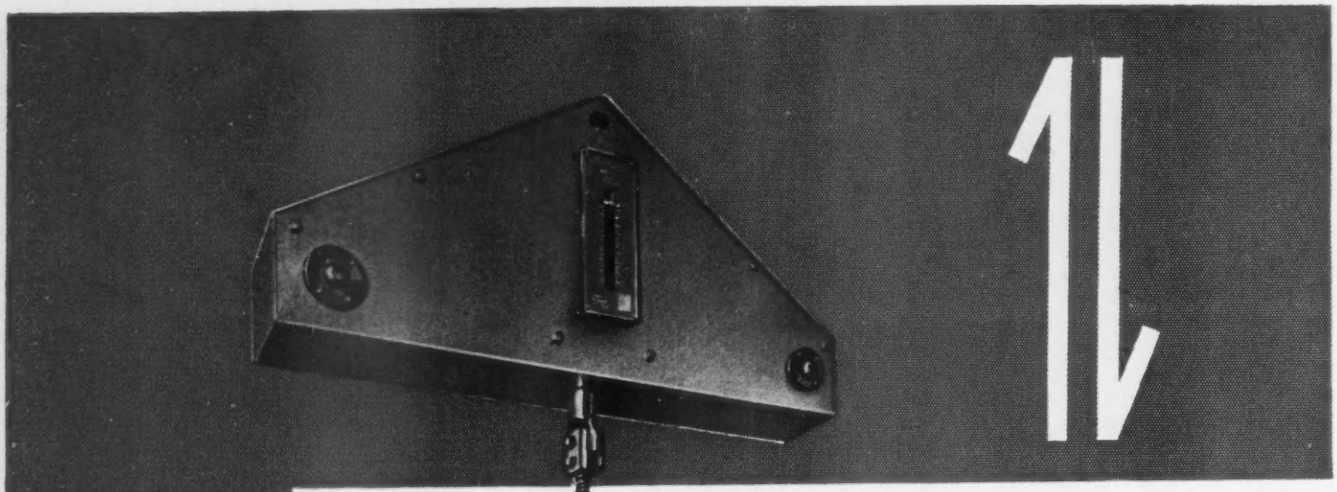
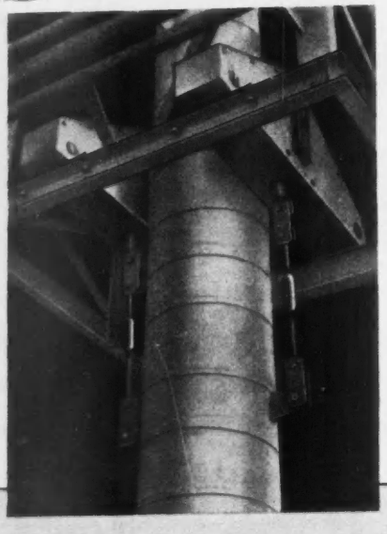


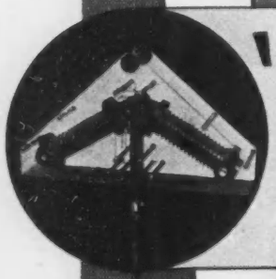
UNRESTRAINED THERMAL PIPE MOVEMENTS



In modern power plants the main high temperature pipework systems are subjected to very large thermal movements and, if dangerous stress intensifications in the pipe walls and at terminal connections are to be avoided, it is essential that the support hangers balance the weight of the pipework and do not restrain its free expansion and contraction.

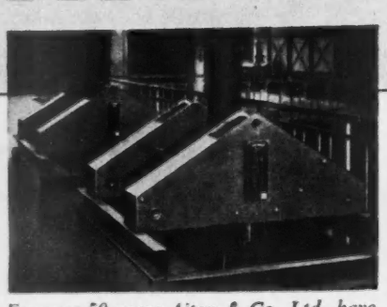
The Mark 1 UNILOAD constant load pipe support developed by Aiton & Co. Ltd. has proved an efficient and reliable unit. Many hundreds have been installed in power stations and industrial plants throughout the world.

Continuous research and development has enabled improvements to be effected in order to increase the range of application of this supporting unit. The Mark 2 UNILOAD, whilst embodying the tried and proved design features of the original unit, incorporates additional compensating equipment which ensures that the load deflection curve will not vary from the ideal straight line by more than plus or minus 2% of the rated load.



'UNILOAD' CONSTANT LOAD PIPE SUPPORTS

MARK 1 AND MARK 2



The Mark 2 UNILOAD is particularly suited to nuclear power plant or for any application where exceptional accuracy in load carrying characteristics are demanded.

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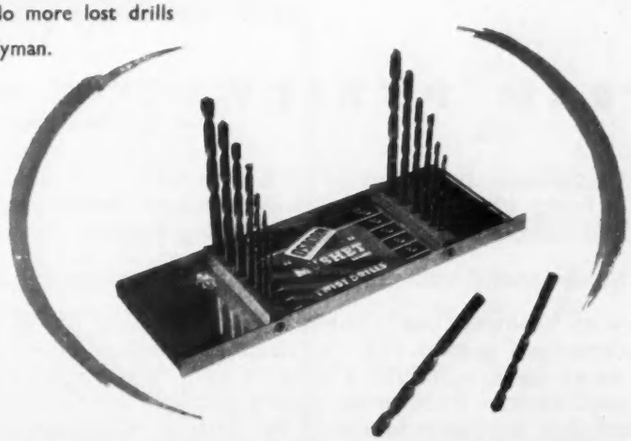

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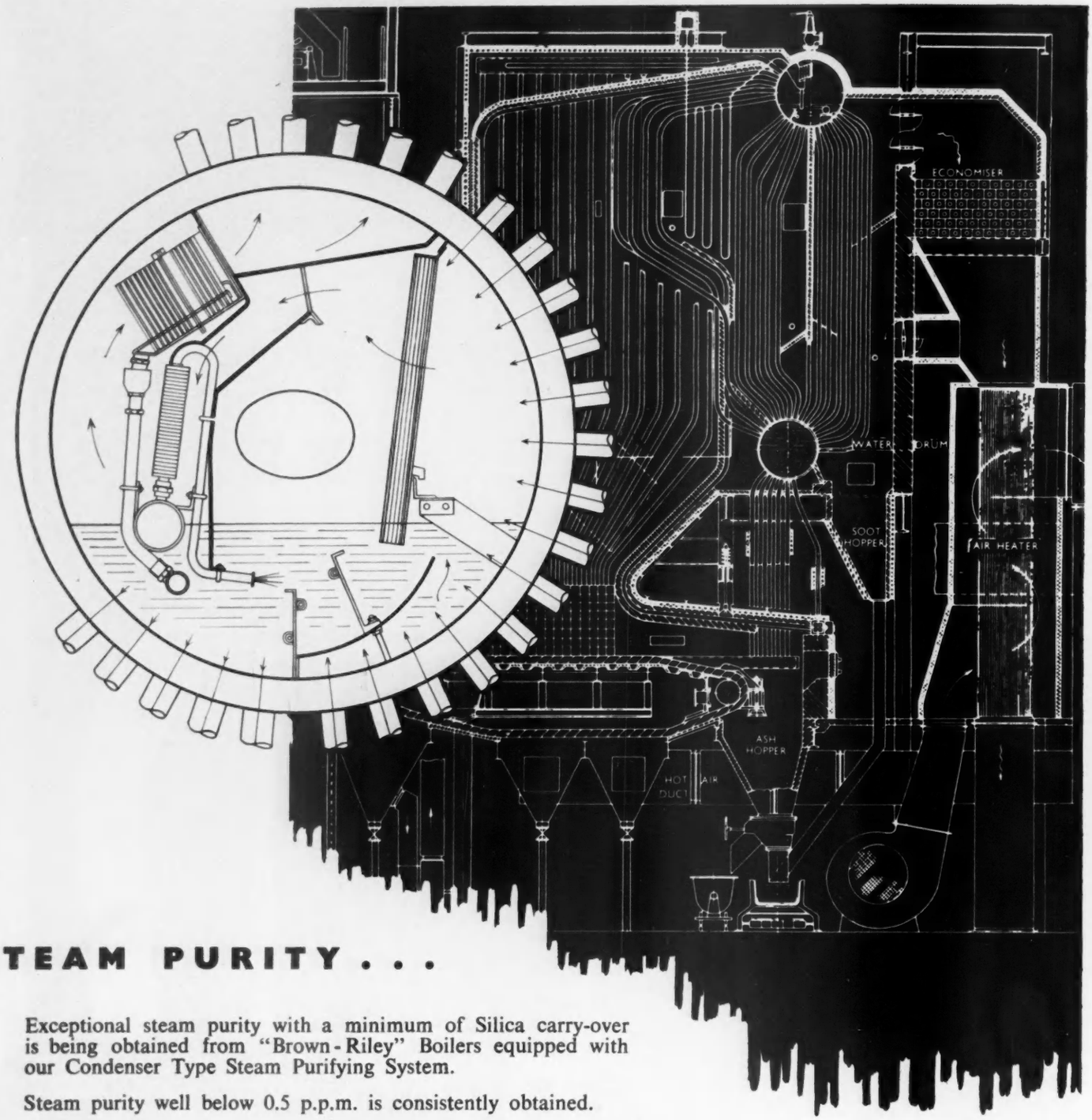

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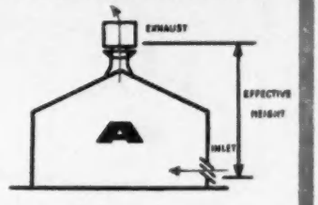
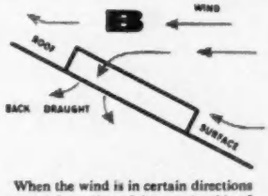
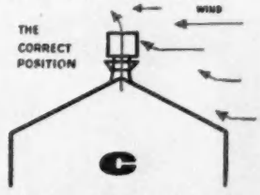


For maximum efficiency, natural ventilators must be sited as high, intakes as low as possible.



When the wind is in certain directions a natural ventilator lying on the side of a roof will probably backdraught.



A ventilator mounted on the ridge, as shown, with its outlet horizontal will give maximum, positive exhaust under all conditions of wind.

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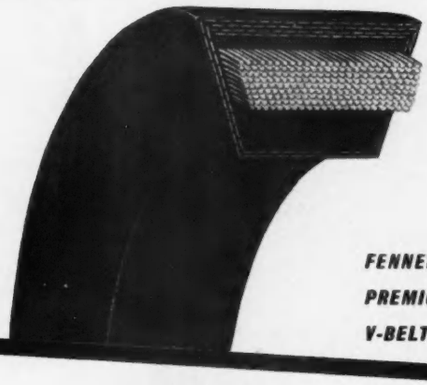

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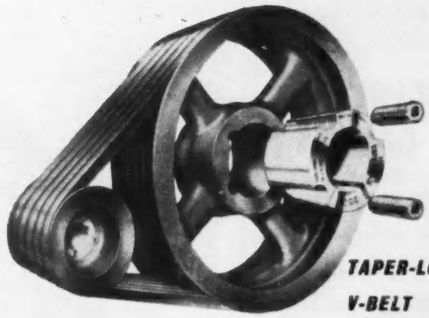

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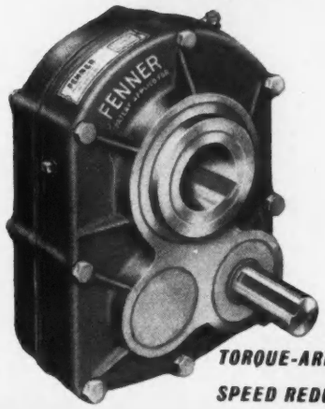

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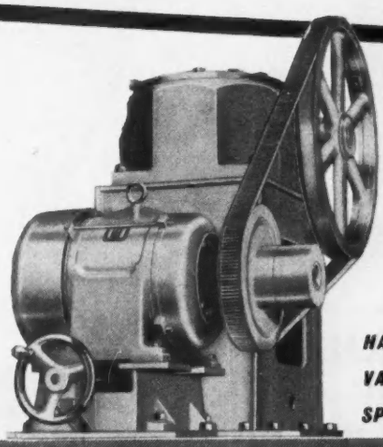

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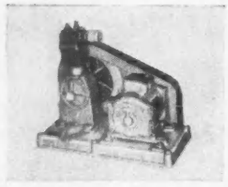

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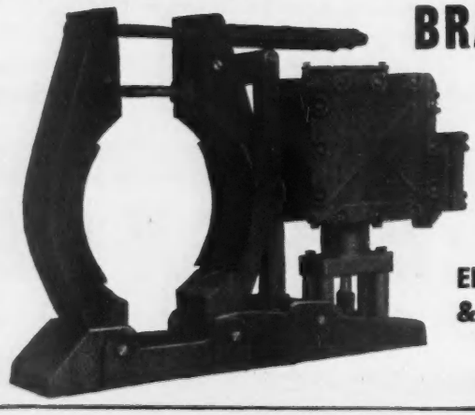

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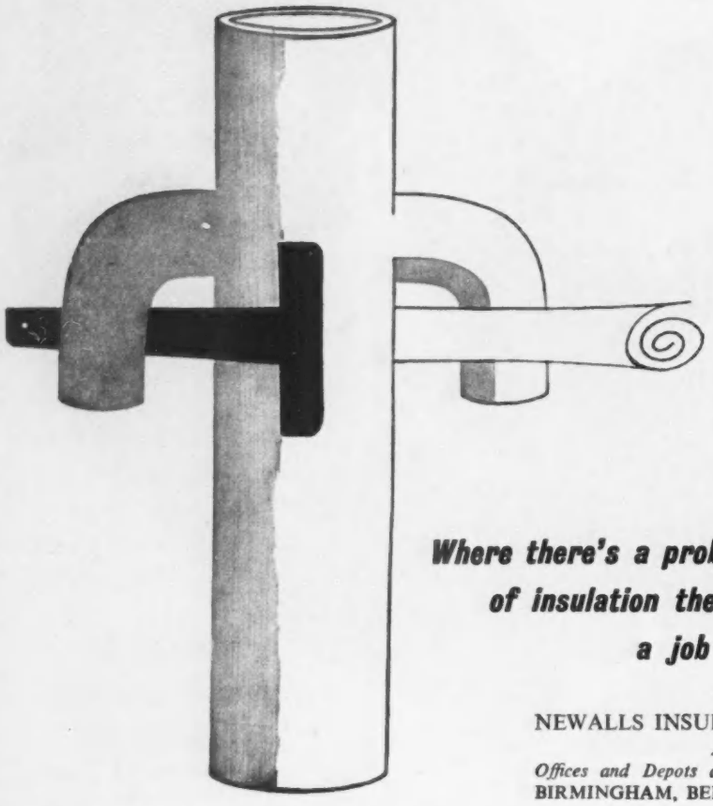

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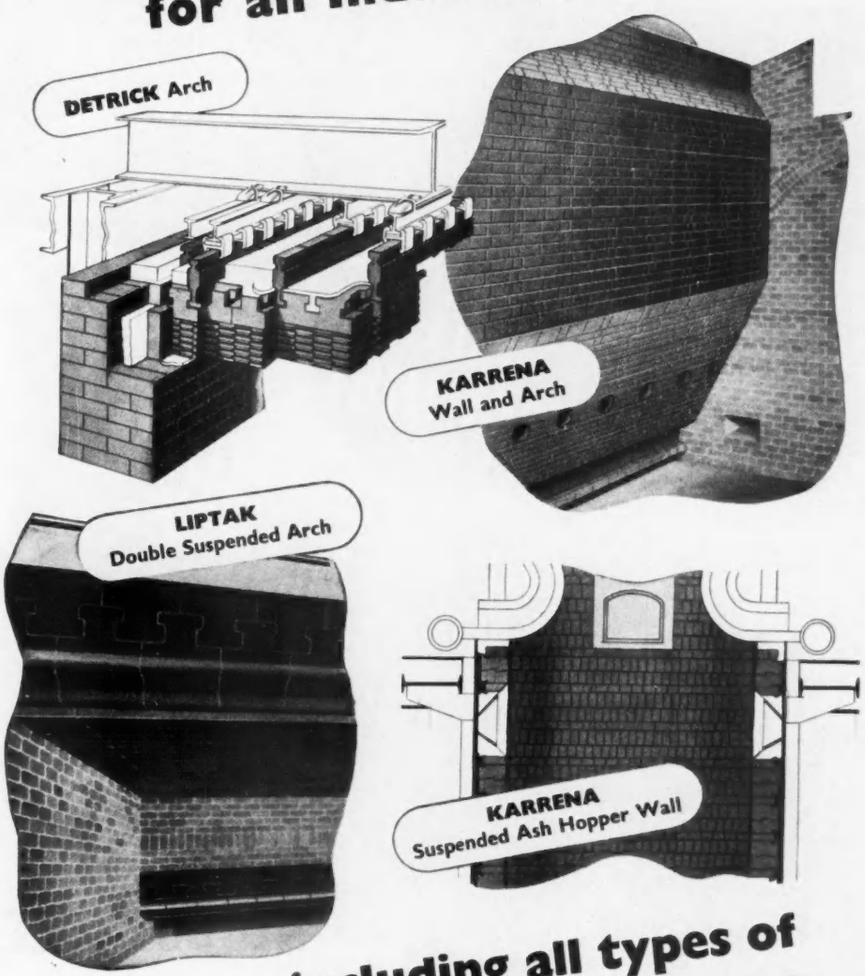

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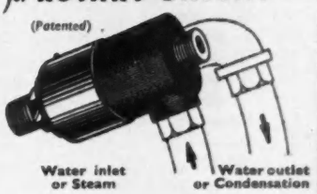

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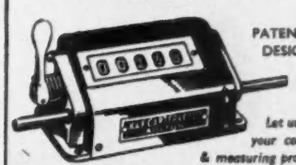

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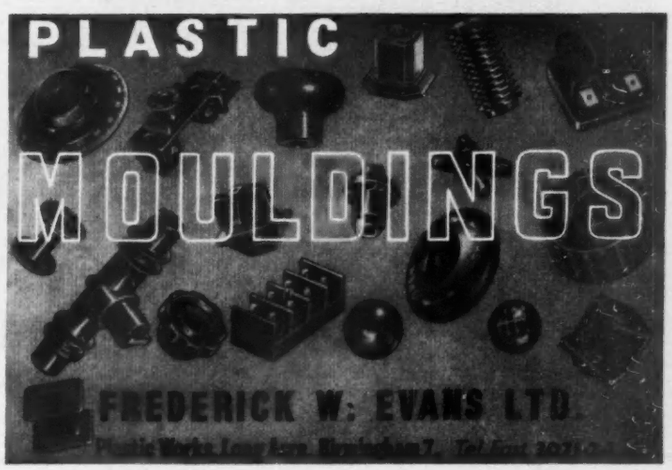

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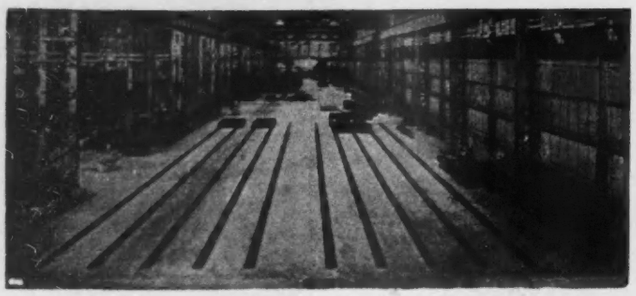

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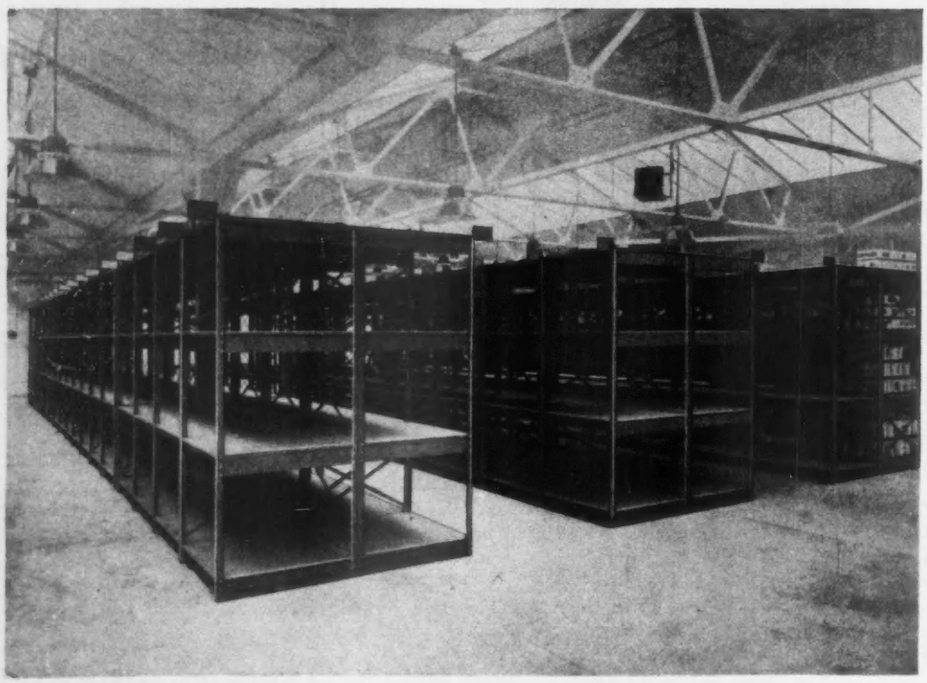

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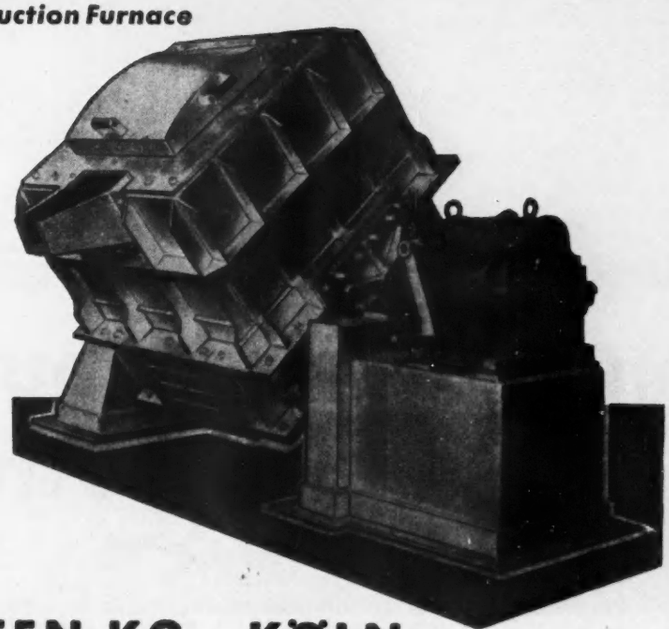

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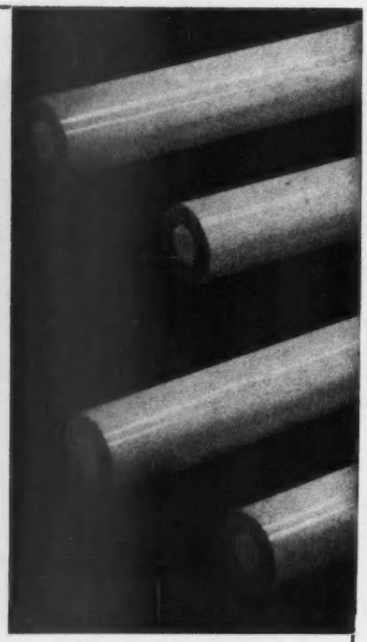

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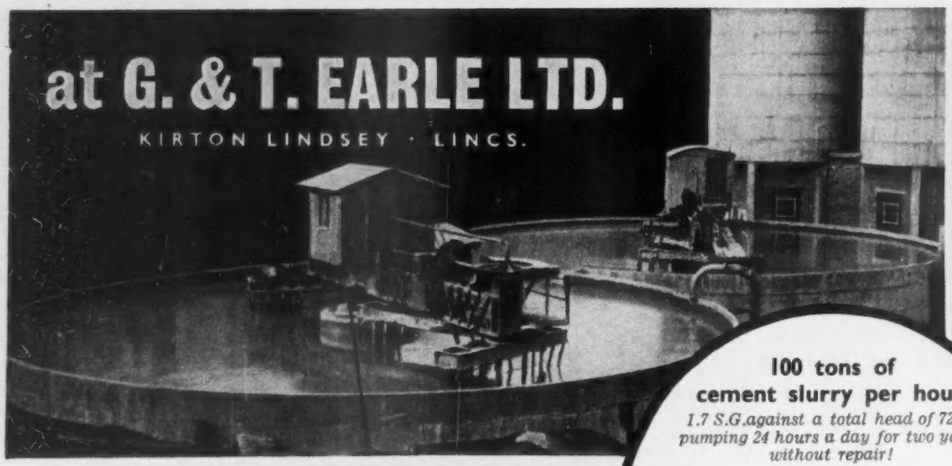

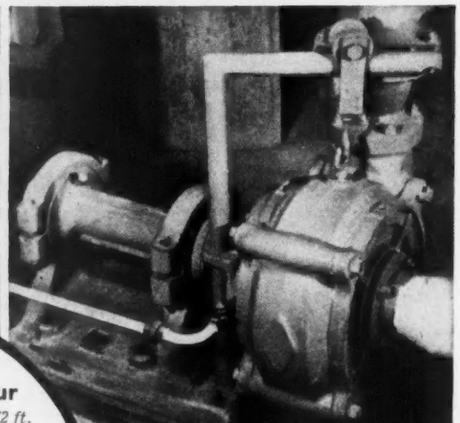

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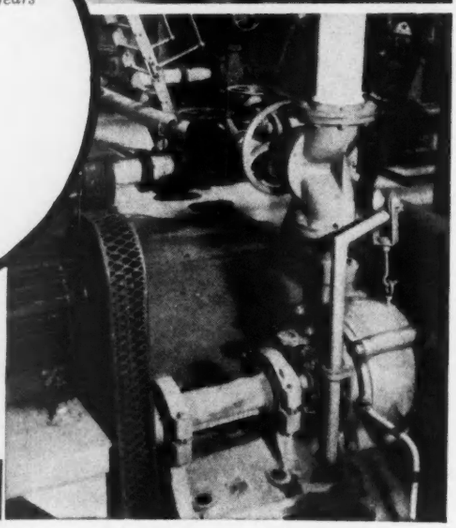

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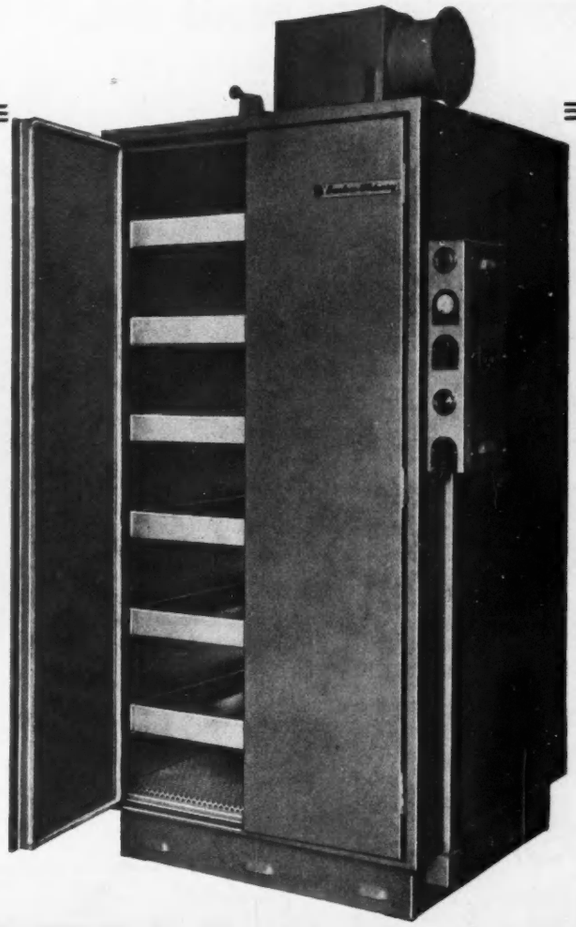

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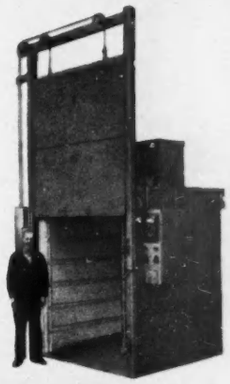

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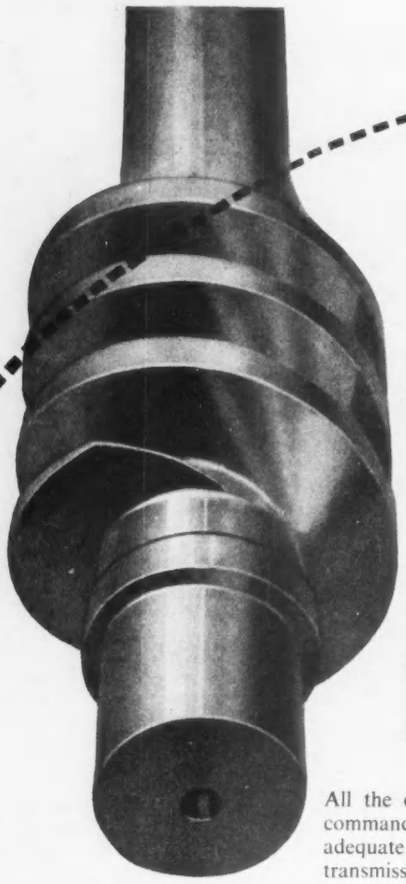

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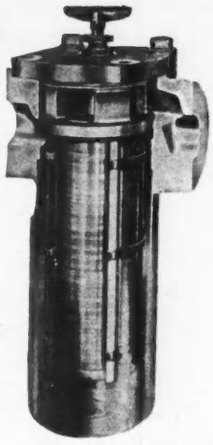

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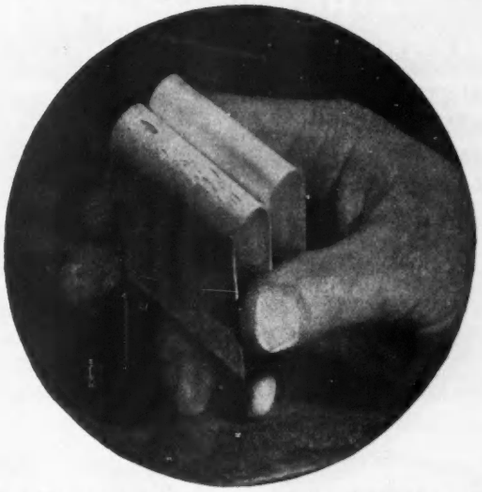

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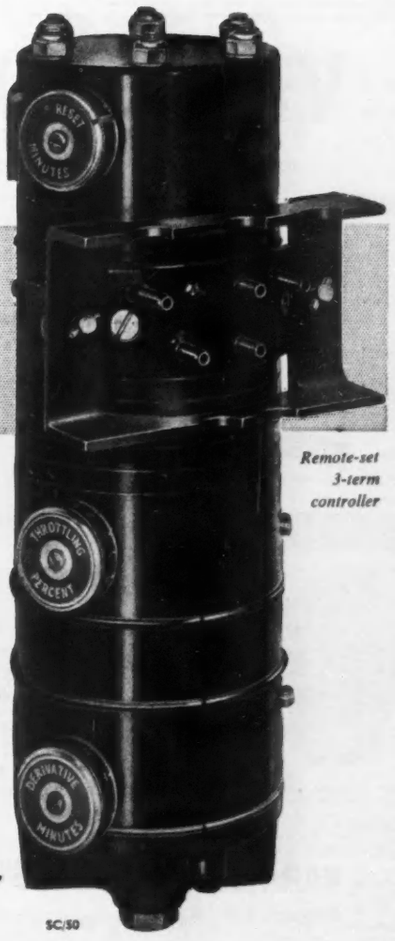

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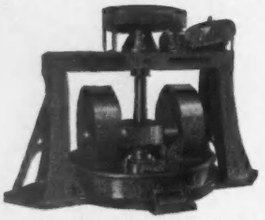

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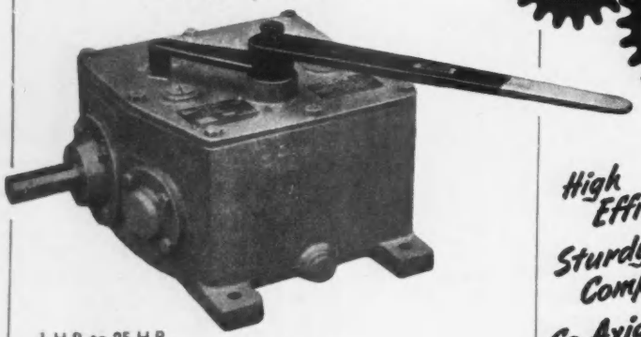

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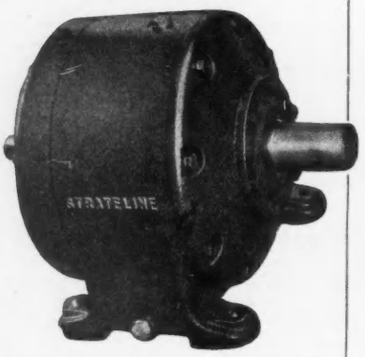

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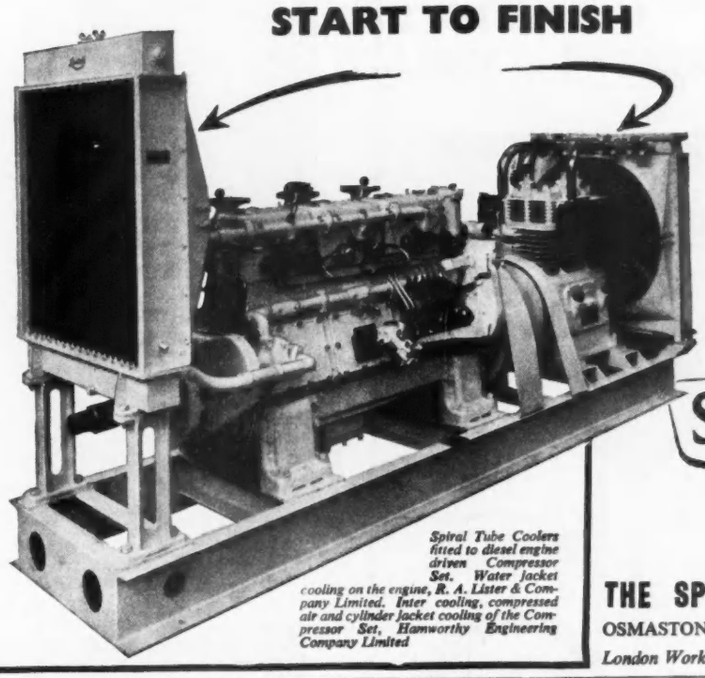

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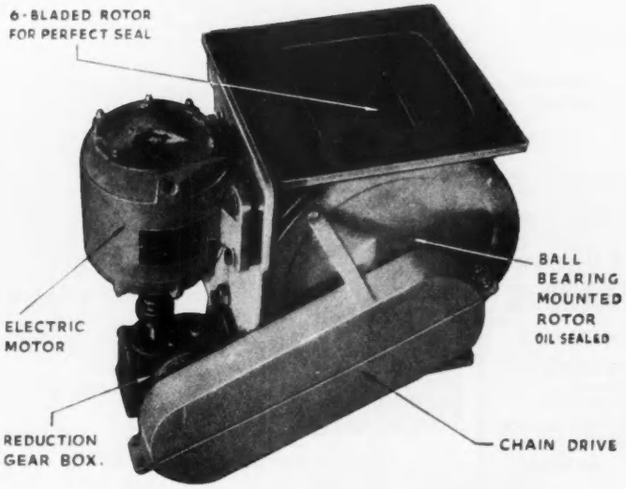

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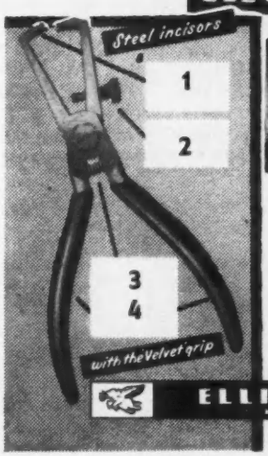

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1 Hardened & Tempered steel jaws will cut through toughest casing with ease.
2 Knurled micro-adjustment screw prevents accidental cutting of wire.
3 Opening Spring for quick repetition work.
4 Red P.V.C. covering to handles—for slip prevention and quick identification.

ELLIOTT-LUCAS
LIMITED
CHURCHBRIDGE WORKS, CANNOCK. STAFFS.

for accurate measurement choose

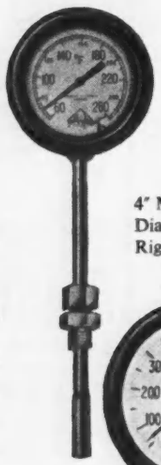
NEGRETTI & ZAMBRA

precision-made Thermometers

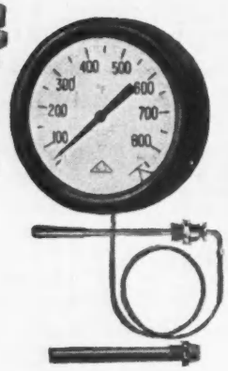
Dipping Thermometer
for hot water, etc.

Room Thermometer
with plastic case

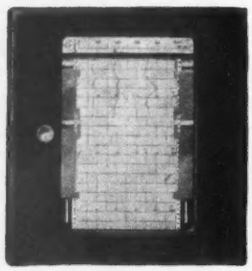
Brass-cased Tank and
Pipe Thermometer



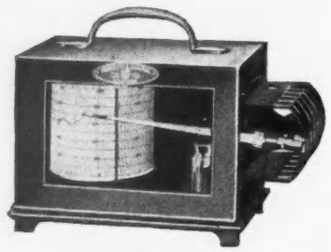
4" Mercury-in-steel
Dial Thermometer,
Rigid Stem Type



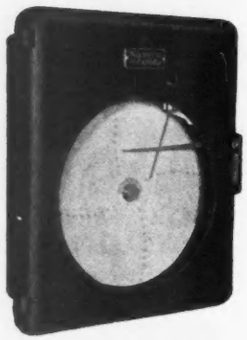
Distance-type Mercury-in-
steel Dial Thermometer



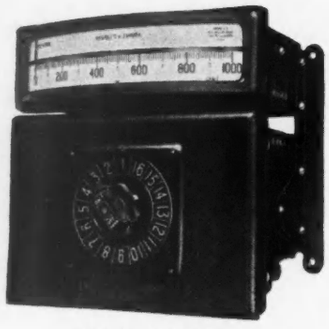
Resistance Thermometer
Recorder



Bi-metallic Recording
Thermometer



Mercury-in-steel Disc
Chart Recorder



Multi-point Indicator
Pyrometer

For complete technical literature about
Thermometers write to:—

NEGRETTI & ZAMBRA

NEGRETTI & ZAMBRA LTD., 122 REGENT STREET, LONDON, W.1.

Telephone: REGent 3406 *Telegrams: NEGRETTI PICCY LONDON*

Branches at: Birmingham, Cardiff, Glasgow, Manchester, Leeds,
Nottingham. Agents or subsidiaries in most countries.

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/-, which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

Advertisements for publication should be addressed to:— **Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

UNIVERSITY OF QUEENSLAND, AUSTRALIA

LECTURERS

Applications are invited for the following positions: (I) CHIEF LECTURER or SENIOR LECTURER IN MECHANICAL ENGINEERING. Salary £A2560/£A2800 or £A2160/£A2510 p.a., respectively, according to qualifications and experience. Applicants should have a Degree or Higher Degree in Engineering of a recognised University, together with design experience in industry and teaching experience at University level in design subjects. Applications close 30th June, 1958.

(II) SENIOR LECTURER IN CIVIL ENGINEERING. Salary £A2160/£A2510 p.a. Applicants must hold a Degree in Civil Engineering, preferably a Higher Degree, and have had some experience in the design and construction of engineering works. Experience in lecturing and research is desirable. The appointee will be required to take part in hydraulic model investigations, other hydraulic studies and soil mechanics investigations. Applications close 30th June, 1958.

(III) LECTURERS (2) IN MECHANICAL ENGINEERING. Salary £A1540/£A2040 p.a. Applicants should have a Degree in Engineering, preferably with honours and some industrial or research experience. For one position an interest in applied mechanics and theory of machines is necessary, and for the other an interest in drawing and design. Applications close 30th June, 1958.

Further particulars are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1. Applications close, in Australia and London, as above. E7085

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY

LONDON

A SENIOR LECTURER

The College is one of the eight Colleges of Advanced Technology. It is concerned with full-time Degree, Sandwich Diploma in Technology and Advanced courses in Engineering and Applied Science.

A SENIOR LECTURER is required in the Department of Instrument Engineering to commence duties from September, 1958. Candidates should be Graduates or possess equivalent qualifications; they should have had some experience in the instrument engineering or manufacturing industries, including automatic control systems.

Salary scale £1386, rising, by annual increments, to £1598 p.a. Additional increments above the minimum granted for industrial or research experience if approved as of equivalent standard.

Further particulars and forms of application obtainable from the Secretary, Northampton College of Advanced Technology, St. John Street, E.C.1. E7072

NORTH LINDSEY TECHNICAL COLLEGE

KINGSWAY, SCUNTHORPE, LINCS

Principal:
F. C. JONES, B.Sc. (Eng.), A.M.I.Mech.E., A.M.I.E.E.

DEPARTMENT OF SCIENCE AND METALLURGY

LECTURER

Applications are invited for the post of LECTURER IN METALLURGY, duties to commence on 1st September, 1958.

The Lecturer appointed would be required to teach mainly General Metallurgy to Ordinary National Certificate classes and specialise in Physical Metallurgy and/or Metallurgical Analysis to Higher National Certificate and possibly I.I.M. classes.

A candidate should hold a University Degree or equivalent qualification.

Forms of application and further information may be obtained from the Principal at the above address, to whom completed forms should be returned not later than 22nd May, 1958.

Salary in accordance with Burnham Technical Scale for Teachers in Technical Colleges, i.e. Lecturer, £1200–£1350 per annum. E7083

WILTSHIRE EDUCATION COMMITTEE

NORTH WEST WILTSHIRE AREA COLLEGE OF FURTHER EDUCATION

LECTURER

Applications are invited for the post of LECTURER, to be responsible for Mechanical Engineering subjects, including Engineering Drawing to Higher National Certificate standard. Vacant as from 1st September, 1958.

Applicants should be Graduates or possess equivalent qualifications and should have had good teaching and industrial experience.

Application forms and further details from the Principal, Cocklebury Road, Chippenham. E7053

WORCESTERSHIRE EDUCATION COMMITTEE

COLLEGE OF FURTHER EDUCATION, BROMSGROVE

APPOINTMENTS

Applications are invited for the following:—

(a) LECTURER IN MANAGEMENT STUDIES. Candidates should have appropriate academic qualifications and industrial experience, as well as previous teaching experience. The work will be mainly concerned with the development of Management Courses in the Commerce and Engineering Departments of the College. Salary: £1200 by £30 to £1350.

(b) GRADE A or GRADE B, to teach Machine Shop Engineering subjects up to Intermediate City and Guilds level. This post will be Grade A or Grade B, according to experience and qualifications. Salary: Grade B, £650 by £25 to £1025; Grade A, £475 by £25 to £900.

Particulars of the above posts and application forms may be obtained from the Chief Education Officer (S/J), County Education Office, Castle Street, Worcester, on receipt of a stamped, addressed foolscap envelope (4½d.). (E190.) E7091

THE POLYTECHNIC, REGENT STREET, W.1

CIVIL AND MECHANICAL ENGINEERING DEPARTMENT

ASSISTANT (GRADE B)

Applications are invited for the post of full-time ASSISTANT (GRADE B) to teach Metrology and Workshop Technology.

The Salary scale rises to a maximum of £1025 per annum, plus allowances for graduate status (£75), training (£25–£75) and London (£36–£48).

The commencing salary will depend upon qualifications and experience and may include up to twelve increments in respect of approved service in industry. The post is subject to superannuation and some concession in this respect may be made for previous industrial employment.

Further particulars and a form of application, which should be returned by not later than 19th May may be obtained from the undersigned.

J. E. RICHARDSON,
Director of Education.
E7075

UNIVERSITY OF MANCHESTER

LECTURER IN ENGINEERING (MECHANICAL)

Applications are invited for two posts of LECTURER IN ENGINEERING (MECHANICAL). For one post a prime interest in thermodynamics applied to heat engines is required; for the other interests in applied thermodynamics, heat transfer, mechanisms or machine design. University regulations permit teaching staff to read for the Degrees of M.Sc. and Ph.D. The salary scale is £900 to £1650 per annum. Membership of the F.S.S.U. and Children's Allowance Scheme. Initial salary according to qualifications and experience.—Applications should be sent not later than May 24th, 1958, to the Registrar, The University, Manchester, 13, from whom further particulars and forms of application may be obtained. Applications by airmail (no forms) will be considered from overseas candidates. E6994

BUCKINGHAMSHIRE EDUCATION COMMITTEE

SLOUGH COLLEGE OF FURTHER EDUCATION

(Principal: R. EDGAR, M.Sc., M.A.)

DEPARTMENT OF ENGINEERING

ASSISTANT (GRADE B)

Applications are invited for the post of ASSISTANT (GRADE B), for Mechanical Engineering, qualified to teach Engineering Science and Drawing with first and second year O.N.C. classes. Candidates should have had appropriate industrial experience and previous teaching (or training).

Salary in accordance with the Burnham Report, viz., £650 by £25 to £1025, with additions for Degree, training and previous industrial experience where appropriate.

Further particulars and forms of application may be obtained from the Principal, College of Further Education, William Street, Slough. E7088

WEST RIDING COUNTY COUNCIL

CASTLEFORD, WHITWOOD MINING AND TECHNICAL COLLEGE

DEPARTMENT OF ENGINEERING AND BUILDING

LECTURER

Applications are invited from Graduates with suitable industrial and teaching experience for the post of LECTURER IN MECHANICAL ENGINEERING, mainly for O.N.C. and H.N.C. Courses and possibly Theory of Machines and Strength of Materials to A.2 level.

Salary in accordance with the Burnham Technical Report, £1200 by £30 to £1350 per annum.

Further particulars and applications obtainable from J. W. Davies, 2, Wesley Street, Castleford. E7056

CHESHIRE EDUCATION COMMITTEE

MACCLESFIELD COLLEGE OF FURTHER EDUCATION

HEAD OF DEPARTMENT

From September, 1958, HEAD OF DEPARTMENT, Grade I, for MECHANICAL ENGINEERING and BUILDING. Good academic qualifications, teaching and practical experience required in Mechanical Engineering. Ability to control and to teach in Aircraft Servicing Courses an advantage.

Salary in accordance with the Burnham Technical Report for 1956, with appropriate additions for industrial and teaching experience.

Application form obtainable by sending a stamped, addressed, foolscap envelope to John G. Kellett, Director of Education, County Hall, Chester. E7112

CIVIL SERVICE COMMISSION

MINISTRY OF POWER

INSPECTORS OF MECHANICAL ENGINEERING

INSPECTORS OF MECHANICAL ENGINEERING in Mines and Quarries. Three pensionable posts for men at least 27 on 1st April, 1958, who have achieved Corporate Membership of Institution of Mechanical Engineers or have passed examinations recognised for the attainment of such membership and have held senior responsible post to do with mechanical engineering plant at coal mines for at least two years since 1952. National salary scale £1850 to £2050. Promotion prospects.—Write, Civil Service Commission, 30, Old Burlington Street, London, W.1, for application form, quoting S4837/58/8. Closing date 20th June, 1958. E7071

NATIONAL COLLEGE FOR HEATING, VENTILATING, REFRIGERATION AND FAN ENGINEERING

AT THE BOROUGH POLYTECHNIC, BOROUGH ROAD, LONDON, S.E.1

Director: JAMES E. GARSIDE, M.Sc.Tech. Ph.D., F.R.I.C., F.I.M., M.Inst.F.

HEAD OF THE COLLEGE

The Board of Governors of the above-named National College invite applications for the post of HEAD OF THE COLLEGE, as from 1st September, 1958.

Candidates should possess a good Honours Degree in either Engineering or Physics, and have had relevant research or industrial experience.

In addition to organisational and teaching duties the candidate appointed will be expected to initiate research and supervise the active research programme of the College.

The number of students is increasing and to meet the increased demand for accommodation the erection of a new building for the College on a nearby site will shortly commence.

Salary: £1800 by £50 to £1950 p.a.

Further particulars and form of application may be obtained from the undersigned.

FREDK. J. PACKER,
Clerk to the Governors.
E7177

CITY OF CARDIFF

CORPORATION WATERWORKS

APPOINTMENTS

Applications are invited for the following permanent appointments on the staff of the Water Engineer and Manager.

RESIDENT ENGINEER (A.P.T. IV, £1025–£1175 per annum) at the Corporation Reservoirs and Treatment Works.

Applicants must have had experience on maintenance of catchment area, impounding reservoirs, treatment, pumping plant and trunk mains. Housing accommodation will be available at a reasonable rent.

ENGINEERING ASSISTANT (Special Classes Grade, £750–£1030 per annum).

Applicants must have passed Sections "A" and "B" of the Associated Membership Examination of the Institution of Civil Engineers or possess an Engineering Degree giving exemption therefrom.

General conditions and further details of these appointments can be obtained from the Water Engineer and Manager, City Hall, Cardiff, and applications, stating age, previous experience and qualifications, together with the names of two referees, should reach the undersigned, in envelopes appropriately endorsed, not later than Tuesday, the 20th May, 1958.

S. TAPPER JONES,
Town Clerk.

City Hall,
Cardiff,
28th April, 1958. E7035

EASTERN REGIONAL HOSPITAL BOARD, SCOTLAND

APPOINTMENTS

Applications are invited for the following post in the Department of the Regional Engineer:—

(a) ASSISTANT ENGINEER. Qualification: G.I.Mech.E. or A.M.I.H.V.E. or equivalent. Salary £700 by £25 (3) by £30 (1) by £35 (6) to £1015 per annum.

OR

(b) ENGINEERING ASSISTANT (GRADE I), Qualification: H.N.C. (Mechanical) or equivalent. Salary £655 (at age 23 or over) by £25 (4) by £30 (1) by £35 (4) by £40 (1) to £965 per annum.

Candidates should be either (i) experienced designers and draughtsmen in boiler plant heating, ventilating and steam services, &c., or (ii) otherwise experienced in similar work and in fuel efficiency control of such plant. Hospital experience desirable, but not essential.

Applications, giving particulars of age, education, experience and names of three referees (two of whom should be technically qualified), to be lodged with the Secretary to the Board, 430, Blackness Road, Dundee, not later than 16th May, 1958. E7086

Classified Advts. continued on page 122

PUBLIC APPOINTMENTS

PUBLIC WORKS DEPARTMENT

NORTHERN NIGERIA

SENIOR ELECTRICAL ENGINEER

To be responsible to the Director of Public Works for the operation of an Electrical Branch of the Department. The duties of the Branch will include the preparation and supervision from estimate to completion, of electrical schemes for public buildings, staff quarters, hospitals, schools, water pumping stations, industrial premises, &c. Private oil engine generating plant and overhead distribution will be required for some. The efficient maintenance of these installations, often hundreds of miles apart, is a particular responsibility of the appointment.

Pensionable appointment at a fixed consolidated salary of £2040 p.a. or on contract at a salary of £2448 p.a. In the case of a Contract appointment, a Gratuity of £37 10s. for each completed three months' satisfactory service would be payable. Quarters, if available, at low rental. Free passages for officer and up to two adult passages for wife and children. Special allowance of £120–£288 p.a. may also be paid for maximum of three children under 18. Outfit allowance of £40 payable on first appointment. Generous leave.

Candidates, between 35 and 40, must be Corporate Members of the Institution of Electrical Engineers. The possession of a good degree will be an advantage. They must have specialised in Electrical Installations and have had a minimum of ten years' responsible experience in design and maintenance of electrical installations in large public and institutional buildings. Experience of the special requirements of low-cost electrical installations in under-developed tropical countries an advantage.

Write Director of Recruitment, Colonial Office, London, S.W.1, giving age, qualifications and experience. Quote BCD.112/408/05. E7080

SOUTHEND WATERWORKS COMPANY

APPOINTMENT OF ENGINEERING ASSISTANT

Applications are invited for the post of ENGINEERING ASSISTANT, at a commencing salary of £750 per annum.

Candidates must have passed Parts A and B of the Institution of Civil Engineers or exempting examinations, have had some experience in the design of water retaining structures and in general waterworks practice. Good experience will be obtained on New Works.

The appointment, which will be terminable by one month's notice on either side, will be subject to a satisfactory medical report, after which the applicant will be required to join the Company's superannuation scheme.

Applications, endorsed "Engineering Assistant," stating age, qualifications and experience, and giving the names of two persons to whom reference may be made, should be sent to the undersigned not later than 30th May, 1958.

PETER FRANCIS,
Secretary.

13, Cambridge Road,
Southend-on-Sea,
9th May, 1958. E7105

CITY OF LIVERPOOL

CITY ENGINEER AND SURVEYOR'S DEPARTMENT

ASSISTANT (MECHANICAL ENGINEERING)

Applications are invited for the appointment of ASSISTANT (MECHANICAL ENGINEERING). Salary within N.J.C. scale (£750–£1030 per annum).

Applicants must possess a Higher National Certificate in Mechanical Engineering and have had a recognised training in general mechanical engineering, which must include at least 4 years' drawing-office practice. Some knowledge of automobile engineering and vehicle body design is desirable.

Application form, returnable by 31st May, 1958, can be obtained from the City Engineer and Surveyor, Municipal Buildings, Liverpool, 2.

The appointment is superannuable and subject to the Standing Orders of the City Council. Canvassing disqualifies.

THOMAS ALKER,
Town Clerk.
(J.5162.) E7113

NORTH EAST METROPOLITAN REGIONAL BLOOD TRANSFUSION CENTRE, CRESCENT DRIVE, BRENTWOOD, ESSEX

SENIOR ENGINEER

SENIOR ENGINEER (non-resident) required for duties at the Regional Blood Transfusion Centre and the Brentwood District Hospital and Maternity Home.

Salary in accordance with the appropriate Whitley Council agreement, £685 to £780 per annum.

Applicants must possess a First or Second Class Certificate of Competency in Marine Engineering or equivalent Naval Certificate, or City and Guilds Full Technological Certificate in Plant Engineering First Class, or Ordinary National Certificate in Mechanical Engineering, including Heat and Heat Engines as a subject, and preferably with an Endorsement in the Principles of Electricity.

Candidates should have previous experience in a supervisory position and possess a wide knowledge of the operation and maintenance of boilers, engines and other steam plant.

Application form, returnable by 22nd May, may be obtained from the Group Secretary, Brentwood Group Hospital Management Committee, High Wood Hospital, Brentwood, Essex. E7111

PUBLIC APPOINTMENTS

ADMIRALTY

ROYAL NAVAL SCIENTIFIC SERVICE

DRAUGHTSMEN

DRAUGHTSMEN required in Admiralty Research and Development Establishments in London (Teddington area), Portsmouth, Weymouth and Baldock (Herts), for the design of experimental apparatus needed for fundamental research or for fitting in H.M. Ships. Experience is necessary in any of the following classes of equipment: light to medium electrical, electro-mechanical, precision mechanical and electronic.

Candidates must be British, aged 21 years or over, with at least three years' practical workshop training and, preferably, with drawing-office experience and possession of the O.N.C. or equivalent.

Appointments unestablished but opportunities will occur to compete for established posts and for promotion.

Starting pay (London) £550 (age 21); £755 (age 28): scale maximum £870; slightly less in the provinces.

Apply, stating age, training, experience and qualifications, to Admiralty, Queen Anne's Mansions (Room 809), St. James's Park, London, S.W.1. E7052

GOVERNMENT OF UGANDA

SUPERINTENDENT OF APPRENTICESHIP AND TRADE TESTING

SUPERINTENDENT OF APPRENTICESHIP AND TRADE TESTING, preferably between 37 and 47, required to take charge of Apprenticeship and Trade Testing Division of Labour Department, and to supervise and advise on apprenticeship training in industry and Government Departments. Considerable practical experience and first-hand knowledge of apprenticeship training, also administrative ability essential. Degree in Engineering or equivalent professional qualification or appropriate engineering experience in Her Majesty's Forces necessary. Post on contract/resettlement grant terms for one tour of 30–36 months. Home pension rights preserved. Salary at appropriate point in scale £939 to £1863 inclusive. Quarters, when available, at low rental. Free passages and medical attendance. Outfit, education and separation allowances. Generous home leave. Low income tax.—Further particulars and application forms obtainable from Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.132/9/06. Closing date for receipt of initial enquiries 31st May, 1958. E7032

THE NIGERIAN RAILWAY CORPORATION

DISTRICT ENGINEER

The Nigerian Railway Corporation invites applications for the following post:—DISTRICT ENGINEER.

DUTIES: the officer will be required to direct and supervise the maintenance of way and works and the construction of new works or renewals on a district of the railway.

QUALIFICATIONS: candidates must be Corporate Members of the Institution of Civil Engineers and have at least ten years' experience of maintenance of railway permanent way and works.

SALARY: £2350 per annum. Appointments may be on pensionable terms or on contract with a gratuity payable on completion of contract at the rate of £39 3s. 4d. for each completed month of service.

TOURS: 15 months in Nigeria, followed by 1 weeks' leave on full pay.

QUARTERS: partly furnished quarters are provided at low rental.

ALLOWANCES: there are attractive family, travelling, transport and other allowances.

Send postcard before 30th May, 1958, mentioning the post and this paper for further particulars and application form to:—

The London Representative, Nigerian Railway Corporation, Nigeria House, 9, Northumberland Avenue, London, W.C.2. E7114

CIVIL SERVICE COMMISSION

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

ABERDEEN

SENIOR SCIENTIFIC OFFICER

Ministry of Agriculture, Fisheries and Food: SENIOR SCIENTIFIC OFFICER at Aberdeen.

Pensionable post at Experimental Factory for a Graduate in Mechanical or Chemical Engineering (at least 2nd Class Honours), with ability to carry out research work on equipment for preservation of food. At least 3 years' appropriate post-graduate or other approved experience essential. Age normally 26 to 31. Salary (Men) £1160 (minimum), rising to £1370.

Write, Civil Service Commission, 30, Old Burlington Street, London, W.1, for application form, quoting S.53/58/M.A.F. E7051

MERSEY DOCKS AND HARBOUR BOARD

MECHANICAL DRAUGHTSMAN

Applications are invited for the position of a MECHANICAL DRAUGHTSMAN. Experience in design of steam and hydraulic machinery, also structural steelwork will be an advantage.

Applicants should possess a Higher National Certificate or an equivalent qualification. Salary will be in accordance with the Board's scale—age, qualifications and experience being taken into account.

Applications should be addressed to the Engineer-in-Chief, Mersey Docks and Harbour Board, Dock Office, Liverpool, 3, and received not later than the 19th May, 1958. E7087

TENDERS

INDIA STORE DEPARTMENT

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :—

18053/58/GNK/HAL
DIESEL FORK-LIFT TRUCK, 1200 kgs., —5 off.

18064/58/GNK/HAL
DUPLEX MILLING MACHINE, table size 1000 by 355mm. Minimum clearance between table surface and spindle centre 35mm. Horizontal adjustment of each milling sleeve, 100m.—1 off.

18069/GNK/HAL
HYDRAULIC WHEEL ASSEMBLY PRESS (Railway), capacity 300 tons. Max. wheel dia. 1200mm. Max. distance between ram and centre frame 2900mm. For an integral rail-coach factory —1 off.

18072/GNK/HAL
EXTERNAL PLAIN GRINDING MACHINE for Axles—1 off. Max. dia. 400mm. Max. length 3000mm., smallest dia. 50mm.

The Tender forms with schedules and specifications, which are returnable on Thursday, the 5th June, 1958, may be obtained from the above office (C.D.N. Branch), on payment of a fee (which is not refundable) of ten shillings for each Tender. Applications for Tenders should clearly state the reference numbers of the Tenders required. E7061

COUNTY COUNCIL OF ESSEX

(1) ESSEX INSTITUTE OF AGRICULTURE, WRITTLE, NR. CHELMSFORD
(2) BRAINTREE COUNTY HIGH SCHOOL

The Education Committee of the County Council of Essex invites Contractors, who are willing to Tender for the following work at the above premises, to submit their names to the undersigned not later than Saturday, 17th May, 1958.

The work consists of, in the case of (1):—

(a) Replacement of two existing gravity feed L.P.H.W. heating boilers by oil-fired boilers.

(b) Complete renewal of the existing domestic hot water service installation and conversion to oil firing, including for all incidental builders' work.

And in the case of (2):—

Complete renewal of the existing L.P.H.W. heating and domestic hot water service installations, with conversion to oil firing and including for all incidental builders' work.

The total value of the work, which must be completed before the 30th September, 1958, is estimated at for:

(1) £7500.
(2) £6500.

From the names submitted a Panel of Contractors will be chosen, who will subsequently be provided with drawings and specifications and invited to Tender.

H. CONOLLY, C.B.E., F.R.I.B.A.,
County Architect.

County Hall,
Chelmsford.
May, 1958. E7110

INDIA STORE DEPARTMENT

ROLLER BEARING AXLEBOXES

The Director General of India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :—

	Quantity Nos.
CAST STEEL ROLLER BEARING AXLEBOXES for B.G. Railway Coaches.	1400

Forms of Tender may be obtained from the above address on or after 9th May, 1958, at a fee of 10s., which is not returnable. If payment is made by cheque, it should please be made payable to "High Commissioner for India." Tenders are to be delivered by 2 p.m. on Thursday, 26th June, 1958.

Please quote Reference No. 1/58/DB/RLY.2. E7102

INDIA STORE DEPARTMENT

LAMINATED BEARING SPRINGS FOR B.G. RAILWAY COACHES

The Director General of India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :—

	Quantity Nos.
LAMINATED BEARING SPRINGS FOR B.G. RAILWAY COACHES.	700

Forms of Tender may be obtained from the above address on or after 9th May, 1958, at a fee of 10s., which is not returnable. If payment is made by cheque, it should please be made payable to "High Commissioner for India." Tenders are to be delivered by 2 p.m. on Thursday, 26th June, 1958.

Please quote Reference No. 3/58/DB/RLY.2. E7103

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent. successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E721 E

FREE! Brochure giving details of Courses in Mechanical and Production Engineering, Draughtsmanship, &c., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other professional examinations.—E.M.I. Institutes, Dept. E.30, London, W.4. (Associated with H.M.V.) E972 E

EDUCATIONAL

BRADFORD INSTITUTE OF TECHNOLOGY

(College of Advanced Technology)

Principal:
E. G. EDWARDS, Ph.D., B.Sc., F.R.I.C.
Departments of Electrical Engineering and Physics.

NUCLEAR REACTOR TECHNOLOGY

A six weeks' Full Time Course to be held at The Bradford Institute of Technology
MONDAY, 2nd JUNE, 1958
to
FRIDAY, 11th JULY, 1958
Fee for the Course: £30.

Application forms and further information may be obtained from The Principal, Bradford Institute of Technology, Bradford, 7. E7079 E

SHORT COURSES FOR ENGINEERS

Lectures, practical work, tutorial classes and discussions in stress analysis, electronics, vibration, servomechanisms, gear design, lubrication and other subjects.—Details from Prof. W. A. Tuplin, Applied Mechanics, University, Mappin Street, Sheffield, 1. E7101 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED

AN ASSISTANT TO THE GENERAL MANAGER

is required for the East Midlands Works of a well-known Engineering Company. The position offers wide scope for initiative and prospects are very good. Candidates should have a Degree or equivalent professional qualifications in Mechanical or Civil Engineering, with experience of works management.

Please apply, in strict confidence, giving details of education, experience, age and present salary, to Urwick, Orr & Partners Limited, Urwick House, 29, Hertford Street, London, W.1, quoting reference GRP/1243 on the envelope. E7115 A

Applications are invited from:

(a) ELECTRICAL ENGINEER DRAUGHTSMEN for complete electrical installation and design work, including motor application.

(b) DESIGNER & DETAIL DRAUGHTSMEN for general mechanical engineering, preferably experienced in machine shop practice. Knowledge of platework, pressure vessels and heat exchangers would be advantageous.

(c) SENIOR REINFORCED CONCRETE DESIGNER DRAUGHTSMEN experienced in the design of foundations and structures.

Top salaries. Newly-built semi-detached houses will be available shortly for successful candidates. Allowances made until removal effected. Grant towards removal expenses. Pension and Life Assurance Schemes.—Apply, The Power-Gas Corpn. Ltd. (Inc. Ashmore, Benson Pease & Co.), Stockton-on-Tees. E7100 A

APPLICATIONS ARE INVITED for the following appointment at the CLAYDON, SUFFOLK, Works of THE BRITISH STEEL PILING CO., LTD.:—

SENIOR DESIGNER: DRAUGHTSMAN (minimum qualifications H.N.C. or equivalent).

Age group 28–35 years. Candidates should be capable of accepting responsibility for complete projects.

THIS APPOINTMENT IS PERMANENT AND PROGRESSIVE IN AN EXPANDING ORGANISATION, and the successful candidate will be engaged on interesting work in connection with special crane type structures, hoisting machinery (steam, diesel, electric) and contractors' plant.

Contributory pension scheme in operation. Good canteen facilities. Salary in accordance with qualifications and experience. The works are situated 15 minutes' bus ride from the centre of Ipswich.—Applications to the Parsonnel Officer at the above address. E6886 A

ASSISTANT CIVIL/STRUCTURAL ENGINEERS required by Consultants for design, &c., of important R.C. and steel structures; also maritime works. Experience suitable for professional qualifications. New offices; 5-day week; holidays honoured; salaries by agreement.—Wilton and Bell, Roman House, Cripplegate Buildings, London Wall, E.C.2 (MONarch 6341). E1848 A

ASSISTANT MACHINE SHOP FOREMAN required by old-established company of General Engineers in North Essex, employing about 300. Non-contributory pension, assistance given with moving and housing. Age 28 to 35. Indentured apprenticeship, technical school qualifications and administrative ability essential. Some knowledge of fitting and toolroom work an advantage. Detail employers and experience in chronological order on separate sheet of paper. Commencing salary, £700 to £900, according to experience. All applications will be treated in confidence.—BOX No. E7123, "The Engineer." A

CHIEF DRAUGHTSMAN required for Drawing Office of Structural Department in Stoke-on-Trent. Good salary, pension scheme.—Apply in writing in first instance to General Manager, Shelton Iron and Steel, Ltd., Stoke-on-Trent. E1846 A

SITUATIONS VACANT

BRITISH PETROLEUM COMPANY, LTD., has vacancies for young MECHANICAL ENGINEERS for service with its Overseas Exploration Drilling Operations. Applicants up to 26 years old must have O.N.C. in Mechanical Engineering or equivalent and have served a five-year apprenticeship with a diesel engine manufacturer with experience in fitting, turning and preferably some outside erection work, with subsequent experience in operating and maintaining diesel engines. Experience of steam pumps, engines, boilers and refrigeration advantageous. Attractive salary plus generous allowance in local currency, free passages out and home, free medical attention, good leave arrangements. Kit allowance. Pension scheme.—Write, giving full particulars, quoting F.546, to BOX 3091, c/o 191, Gresham House, E.C.2. E7119 A

CHECKER FOR GAS TURBINE DRAWING OFFICE

Checker required to fill a senior position and to be responsible initially for drawings for new ranges of turbines and some installation drawings. The work is diverse and interesting. Specialised experience on turbines is not essential but applicants should be over 30, have H.N.C. or equivalent and at least 10 years' Drawing Office experience. The Department is expanding and prospects are good. Posts pensionable.—Applications to Manager of Industrial Relations Department, Ruston and Hornsby Limited, Lincoln. E7062 A

COURTAULDS, LIMITED,
have a vacancy for a
POWER STATION SUPERINTENDENT
at their
MAIN WORKS, COVENTRY

An experienced engineer is required to be responsible to the Works Engineer for the safe and efficient operation and maintenance of an industrial power plant comprising five medium-pressure, stoker-fired, water-tube boilers, three pass-out condensing turbines, together with auxiliary equipment.

The candidate must be suitably qualified, have held positions of responsibility and be thoroughly conversant with the problems of steam and power generation in industrial plants of similar type to that outlined above.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds, Limited, 16, St. Martins-le-Grand, London, E.C.1, quoting reference number B.46. E7070 A

CHIEF DRAUGHTSMAN.—Modern light alloy works, Birmingham area, require Chief Draughtsman to take charge of small Plant Drawing Office. Applications are invited from men aged 40–50 with sound general engineering experience on Mechanical, Structural and Hydraulic work. Technical qualifications to at least H.N.C. standard. Preference given to man with A.M.I.Mech.E. Must be capable of original design and have some experience of plant layout. Salary comparable to the post; superannuation scheme in operation. Reply in writing giving the fullest particulars and salary required.—BOX No. E7082, "The Engineer." A

DESIGN DRAUGHTSMEN required for mechanical design of nucleonic instruments. Pleasant working conditions. A.E.S.D. rates or more, according to experience, ability or qualifications.—Apply Chief Draughtsman, Isotope Developments, Ltd., Beenham Grange, Aldermaston, Berks. (Tel.: Woolhampton 451. E7090 A

DESIGN DRAUGHTSMEN

SENIOR INSTALLATION DRAUGHTSMEN

Due to continued expansion, we now have vacancies with prospects of advancement in our Gas Turbine Drawing Office for Senior men to work on the design or installation of new ranges of turbines. Applicants must have at least 5 years' drawing-office experience but not necessarily on turbines and Design Draughtsmen must have H.N.C. or equivalent. Posts pensionable.—Applications to Manager of Industrial Relations Department, Ruston and Hornsby Limited, Lincoln. E7063 A

DESIGNER REQUIRED for modern Rolling Mills and auxiliary equipment.

This post offers every opportunity to the right type of man.

Reply fully, in strictest confidence.—BOX No. E6988, "The Engineer." A

DETAIL DRAUGHTSMAN required, aged 25 to 30, experienced in detail design of small compressor and/or hydraulic components or drawing experience in automobile components. Capable of carrying out simple technical calculations and producing detail drawings without supervision. Applicants with Higher National Certificate in Mechanical Engineering preferred. Work varied and interesting. Post pensionable.—Applications, stating age and experience, to Manager of Industrial Relations Department, Ruston and Hornsby, Ltd., Lincoln. E7107 A

DEVELOPMENT ENGINEER required for mass production precision engineering works in North Midlands. The methods and processes are of a varied nature covering in the main, machining, grinding, assembly and inspection and the appointment is with a view to introducing new and improved methods on a high precision quality product. Applicants, who should be about 35 years of age, must have had good technical and practical experience, possess initiative, discernment and have a flair for experimental work and investigation, will be given guidance and every assistance. Some knowledge of electricity desirable. The position is permanent for a suitable applicant who should derive considerable satisfaction and interest from the work. Housing assistance given. The Company is old established and operates a pension scheme. Reply in confidence giving full particulars of experience, qualifications, salary required and age. No original testimonials please.—BOX No. E7077, "The Engineer." A

DRAUGHTSMAN (MECHANICAL) Intermediate—wanted for Design and Planning Section of progressive organisation. Excellent prospects. Pension scheme.—Write, Chief Draughtsman, Matisa Equipment, Limited, Hanworth Lane, Chertsey, Surrey. E1858 A

DRAWING-OFFICE CHECKER wanted, with at least two years' experience. Must have knowledge of machine tools and sheet metal machine design and detail.—Write full details to F. J. Edwards, Limited, 359, Euston Road, London, N.W.1. E7118 A

ELECTRICAL DRAUGHTSMAN
required by
W. H. ALLEN SONS & CO., LTD.,
BEDFORD
for work on A.C. and D.C. motors and generators.

This is a permanent appointment on interesting work with good prospects.
Generous Pension Scheme.
Assistance towards removal expenses.
Apply in writing, giving full details of experience, to the
PERSONNEL MANAGER,
W. H. ALLEN SONS & CO., LTD.,
BEDFORD. E7008 A

ENGINEERING GRADUATE (Electrical and/or Mechanical). Young man required as JUNIOR ENGINEER for interesting and progressive technical post in the London Head Office of an expanding iron ore mining company. Wide range of matters handled including D/E traction and electric power generation and distribution.—Please write, stating age, qualifications and previous appointments, to BOX TE.324, c/o 191, Gresham House, E.C.2. E7084 A

FIRST-CLASS DESIGN ENGINEER required to assist the Technical Director. Must have broad experience of design and calculations in mechanical and structural engineering. Able to supervise and check draughtsmen, and apply practical outlook. Mechanical handling experience an advantage. Apply, with full particulars, stating age and salary required. First-class conditions. Superannuation.—BOX No. E1812, "The Engineer." A

FOREMAN of outstanding ability required for expanding Sheet Metal Shop with long-term contracts and development projects for many industries.

Practical experience of following essential:—

Large and small stainless steel fabrications, including heavy gauges and general sheet metal work—Argon-Arc and metallic arc welding—development and setting-out—polishing—shop planning and rate fixing.

Strong and responsible disciplinarian.

Prospects and salary will be commensurate with responsibility demanded for this senior staff appointment.

Only those with proven ability in similar position can be considered.

Apply, with full details of apprenticeship and experience, to Managing Director, Geo. Adlam & Sons, Ltd., Parnall Road, Fishponds, Bristol. E1861 A

GRADUATE ELECTRICAL ENGINEER
CHLORIDE BATTERIES, LIMITED

Applications are invited from Graduate Electrical Engineers up to the age of 28 years, who possess a good Honours Degree and who have completed (or will shortly complete) their National Service. We require a man who has the necessary qualities to hold an executive position within a Technical Department. This step will follow the successful completion of the training period, which will include work in a responsible position in the Department.

Comprehensive training will be given in all aspects of storage battery engineering and in all matters relating to the manufacture, design, development and application of storage batteries.

Previous industrial experience—whilst desirable—is not essential.

An attractive salary will be paid during the training period and a non-contributory pension scheme is in operation.—Applications, giving full details of age, qualifications and experience, should be addressed to the Chief Personnel Officer, Exide Works, Clifton Junction, Swinton, Manchester. E7108 A

HEATING ENGINEERS. A Midland Company require a SENIOR DESIGN ENGINEER as Assistant to the Chief Designer. Applicants should have extensive experience in design of industrial installations and be capable of dealing with projects through all stages of negotiation.—Apply, with full details, to Sales Director, BOX No. E7093, "The Engineer." A

JUNIOR DRAUGHTSMAN required. Experience in mechanical handling plant an advantage. Good prospects. British Industrial Sand, Ltd., High Street, Godstone, Surrey. E1852 A

Classified Advts. continued on page 124

BOOKS and PUBLICATIONS

New Books

FLUID MECHANICS for Engineers

By P. S. BARNA, M.E., A.F.R.Ae.S.
N.S.W. University of Technology *57s. 6d.*

In this single volume adequate coverage is provided for students studying for a degree or diploma in Mechanical or Civil Engineering, and parts will be found equally useful for Higher National Certificate Courses. Emphasis is upon the broad representation of the fundamentals and the subjects covered include fluid statics, fluid motion, wing theory, centrifugal pumps, and hydraulic turbines.

AIR POLLUTION

Edited by M. W. THRING, M.A.
University of Sheffield *42s.*

There remains a great gap in our present knowledge of methods for securing cleaner air over our cities, and this book, comprising a series of chapters by experts in the field, makes a considerable contribution towards bridging this gap. Most of the chapters are based on lectures given in a course on Air Pollution at Sheffield University and now presented in a form which makes information available for reference purposes and stimulating reading.

PROGRAMMING for an Automatic Digital Calculator

By K. H. V. BOOTH, B.Sc., Ph.D.
Birkbeck College, University of London *42s.*

This book describes the methods used for programming automatic digital calculators of the type now coming into extensive use. It contains complete details of the library of sub-routines and programmes used on the APEXC calculator and on the various copies of this machine which are either in operation or near completion.

Butterworths Scientific Publications

88 Kingsway, London, W.C.2

COMPANY MEETING

THE HOFFMANN MANUFACTURING COMPANY

RECORD LEVEL OF TURNOVER

MR. J. W. GARTON ON WELL BALANCED SPREAD OF TRADE

The annual general meeting of The Hoffmann Manufacturing Company, Limited, was held on May 1 in London, Mr. J. W. GARTON, J.P. (Chairman and Managing Director), presiding.

The following is an extract from the statement by the chairman, which had been circulated with the report and accounts for the year ended December 31, 1957.

The year 1957, which is now under review, was one of great activity and the recovery in the motor industry led to increased demands being made upon us.

FINANCIAL FIGURES

The profit of the Hoffmann Group for 1957 before taxation, but after all other charges, including Debenture Interest, amounts to £1,291,746, and compares with £1,089,885 for the previous year. Income Tax and Profits Tax absorbs £644,720 against £541,608 in 1956. The net profit of the Group for the year 1957 after taxation is therefore £647,026 and compares with £548,277 for 1956.

This successful result was achieved by the turnover for the year reaching a record level reflecting the increased productivity brought about by the new plant and machinery we have been installing over the last few years and new methods.

The question of the Ordinary Dividend has again been given very careful consideration by the Directors and they recommend a Final Dividend of 14 per cent., free of tax, which, with the Interim Dividend already paid of 3½ per cent., free of tax, is an increase of 5 per cent., free of tax, on last year.

The Directors have again had pleasure in granting a sum of £25,000 to the Group Benevolent Funds to provide extra pensions to retiring employees, and this amount is being contributed as to £20,000 by the Parent Company and £5000 by Hoffmann Gloucester, Ltd.

CAPITAL EXPENDITURE

Orders for capital commitments at the 31st December, 1957, amounted to £706,029. An appreciable portion of this sum is in connection with the purchase from the Government of a factory building which was erected several years ago and rented to us. The purpose of this building was to house special machinery for making a type of bearing for which the demand did not reach that anticipated. We had in the Agreement an arrangement whereby we could purchase this property after five years, and we now intend to exercise the option because its ownership, with the whole of its services, will materially help our development programme in that area, as it will automatically free us from certain obligations regarding the development of an adjacent piece of land.

The demand for certain sizes of bearings has been in excess of our availability to supply with our existing equipment, but we have now been able or purchase several large automatics and these are helping production of the sizes demanded; when these and others, which we shall purchase during the present year, are in full operation, we shall be able to increase our production appreciably and reduce costs.

BALANCE SHEET

The value of stocks at the 31st December, 1957, has risen by £244,667 after allowing for the increase in the Group Stock Reserve of £25,000 which the Directors have made this year. The higher level of turnover and the increased production it requires are reflected in the higher stock level. There are also larger raw material stocks to ensure uninterrupted manufacturing programmes.

The liquid resources at the end of the year totalled £2,714,137, which compares with £2,279,569 at the 31st December, 1956.

The excess of current assets over current liabilities at the close of 1957 amounted to £3,873,883, compared with £3,359,078 at the close of 1956.

SUBSIDIARY AND ASSOCIATED COMPANIES

Hoffmann Gloucester, Ltd., has again made a very valuable contribution to the Group turnover and has had a successful year. I have referred elsewhere to the intention of this Company to purchase factory premises from the Government, the amount involved being provided from its own resources.

Hoffmann Tweedales, Ltd., in which Hoffmann Gloucester, Ltd., has a 50 per cent. holding, continued to operate at a lower level of profit due to its reduced output, which reflects the lower demand for its products from the Textile Machinery trade at home and abroad and keener world competition.

With regard to the outlook for the future, I can say that the Company's plant is very well employed and our trade well balanced over many industries. There is a substantial order book and although one begins to see a slight falling off in certain directions, particularly in the general engineering industry, there is no reason to suppose, unless anything unforeseen happens, that we should not have a reasonably successful year in front of us. The Company is well equipped to trade successfully in the much harder and more competitive times ahead.

I would like to extend on behalf of the Board sincere thanks to the Executives, Staff and Workpeople for their work during the past year.

The report and accounts were adopted.

SITUATIONS VACANT

INSTRUMENT ENGINEER

An Assistant Instrument Engineer is required to assist in the development of automatic process control in a large modern paper mill. Applicants should have completed an engineering apprenticeship and hold H.N.C. Some instrument experience desirable, although training will be given. Age about 25. Non-contributory pension scheme. Assistance with housing.

Apply in writing, stating age, experience and qualifications, to the Personnel Manager, Aylesford Paper Mills, Larkfield, Nr. Maidstone, Kent. E7067 A

MANAGING DIRECTOR of Engineering Works with approximately 150 personnel engaged in manufacture of Mining Machinery, due to retire in two years, wishes to appoint man with suitable Engineering and Commercial training, to take over Management. Write, giving fullest details respecting qualifications, experience, age and salary required.—BOX No. E1823, "The Engineer." A

MECHANICAL AND ELECTRONIC ENGINEERS AND PHYSICISTS

BRITISH NYLON SPINNERS LIMITED invite applications from Physicists and Corporate or Graduate Members of the Institutions of Mechanical and Electrical Engineering to keep pace with expansion in their Design, Research and Experimental teams.

The work covers an extensive range of engineering problems. Some can be solved by current techniques but may require original research. Others necessitate fundamentally new ideas.

The problems are concerned with the Development and Automation of Nylon Melt-Extrusion and Yarn Processing and measurement. They include electronic circuit design, precision mechanisms, heat transfer and servo control systems.

Knowledge of the textile industry is unnecessary: more important is the zest and capability for original work which will be done under ideal conditions with up-to-date equipmen..

The Company will welcome enquiries, which will be treated in strict confidence and should be addressed to the Personnel Manager, Pontypool, Mon. E7023 A

MECHANICAL DRAUGHTSMAN.—Large commercial organisation has vacancy in London Head Office for a Senior Mechanical Draughtsman, to take charge of Drawing Office. Preference will be given to applicants who hold a Degree in Engineering and who have had good practical experience in refrigeration, boiler installations and electrical work. Some knowledge of building construction would be an advantage. Permanent, pensionable position with good prospects for the right man. Apply in writing, giving age and details of qualifications and experience.—BOX No. E6945, "The Engineer." A

MECHANICAL ENGINEER, A.M.I.Mech.E. 34/45, required for Iran staff of Rendel, Palmer and Tritton, Consulting Engineers. Experience on pipelines and oil pumping an advantage. Should have some design experience. Salary according to qualifications but not less than £2500 p.a., free of Iranian Income Tax and with free accommodation.—Send fullest particulars to Staff Officer, 125, Victoria Street, S.W.1.

E6992 A

OUR RESEARCH AND DEVELOPMENT DEPARTMENT has just moved to completely new laboratory premises and we now have room for a few more ENGINEERS and RESEARCH ASSISTANTS of various grades to help develop a wide variety of products and to solve associated heat exchange and fluid flow problems. If you are interested, and prepared to work in Birmingham, apply to us, in confidence, stating full particulars of education, age, experience and qualifications.—BOX No. E7074 "The Engineer." A

PETROCHEMICALS LIMITED

invite applications

from suitable applicants

for a position at their Partington Works

for an

ASSISTANT INSPECTOR

of

PRESSURE VESSELS AND ASSOCIATED PLANT.

Applicants should be about 30 years of age and should possess a Second Class M.O.T. Certificate (Steam) or have equivalent qualifications and suitable experience. Salary will be commensurate with age and experience. Excellent working conditions and contributory pension fund. Written applications, quoting reference A1/11, should be addressed to:

STAFF MANAGER,

Personnel and Industrial Relations Department, Petrochemicals, Ltd., Partington Industrial Estate, Urmston, Nr. Manchester. E7076 A

QUANTITY SURVEYOR OR QUALIFIED CIVIL ENGINEER who has done measurement work, aged 30–35, required in Liverpool area, for site measurements in connection with dock construction works. Salary depends on age and qualifications.—Send fullest particulars to Staff Office, Rendel, Palmer and Tritton, Consulting Engineers, 125, Victoria Street, S.W.1. E6990 A

PRESTFIBRE, LTD.,
SPENCERS WOOD, READING

Expanding sales of new process for wood-fibre mouldings for Industry (incl. Motor and T.V.) necessitates:

A MECHANICAL DRAUGHTSMAN

for toolmaking design and master drawings. Excellent prospects for first-rate man with experience. Salary to suit.—Apply to Works Director giving full history. E7092 A

QUANTITY SURVEYOR required for service in Tehran as Assistant Superintendent of Technical Services for the National Iranian Oil Company, supervising, estimating, quantity surveying and material supply sections of their office. Qualifications: University Degree or equivalent and Associate Membership of the appropriate Institution, together with experience as a Quantity Surveyor, with estimating, and must have worked in a recognised Quantity Surveyor's Office.

Age 35/45, salary in accordance with qualifications but not less than £2500 free of Income Tax and with accommodation. Two-year tours. Prospects of continuous long-term appointment if satisfactory.

Write fullest particulars to Staff Officer, Rendel, Palmer & Tritton, Consulting Engineers, 125, Victoria Street, London, S.W.1. E6991 A

REQUIRED.—To take charge of Inspection Department, in London District, technically qualified MECHANICAL ENGINEER with experience of welding pressure vessel, and sheet metal work. Experience of refrigeration an asset but not essential. State age, experience and salary required in confidence.—BOX No. E7109, "The Engineer." A

RESIDENT ENGINEER REQUIRED for mechanical and plant erection work on new oil refinery and chemical plant construction. Should be experienced in use of heavy lifting equipment, pipelines, &c., and control of labour. Commencing salary up to £2000 p.a., according to experience and qualifications. Please write in confidence, giving full details of past employers and contracts carried out.—BOX No. E7045, "The Engineer." A

SENIOR DESIGNER DRAUGHTSMAN with flair for design work, required by small/medium-size engineering firm in South West London, building paper making machinery. Previous experience in this field is not essential but applicants should have qualifications at least equal to Higher National Certificate standard. The work is interesting with opportunities for studying equipment in the field. The prospects are good. Pension scheme. Reply.—BOX No. E7042 "The Engineer." A

SECTION LEADER ELECTRICAL DRAUGHTSMAN and Senior DRAUGHTSMAN required for section handling varied projects, including large plant installations. Section Leader post is a senior staff appointment. Salary commensurate with experience. Interviews arranged to suit applicant.—Write or telephone to Chief Draughtsman, General Engineering Department, Northern Aluminium Company Limited, Rogerstone, Mon. (telephone, Newport 59991/6). E6810 A

SENIOR MECHANICAL ENGINEERING DRAUGHTSMAN required for plant layout and design. General engineering experience desired. Knowledge of rolling mills, conveyors, mechanical handling or furnaces, would be advantageous. Salary commensurate with experience. Interviews arranged to suit applicant.—Write or telephone to Chief Draughtsman, General Engineering Department, Northern Aluminium Company Limited, Rogerstone, Mon. (telephone, Newport 59991/6). E6813 A

SENIOR REINFORCED CONCRETE DESIGNER/DRAUGHTSMAN, experienced in the design of foundations and structures. Top salary. Newly-built semi-detached house available to rent to suitable applicant. Grant towards removal expenses and allowance made until removal effected. Pension and insurance scheme.—Apply, The Power-Gas Corporation, Ltd., Stockton-on-Tees. E7021 A

SENIOR SALES ENGINEER

Well - constituted engineering company, involved mainly in the chemical and petroleum industry, wishes to fill a vacancy for a Senior Sales Engineer.

The successful applicant would be required to take over and develop an existing area in the Northern half of England.

Applicants should be aged 30–40 years, with good qualifications and preferably some knowledge of engineering.

This is a technical appointment which offers good possibilities for the right man, and only those with the necessary qualifications and the personality to make the most of them should apply.

Previous representative experience would be an asset, but is not essential providing the applicant has drive and personality.

Remuneration by salary and expenses, with company motor-car provided. Attractive pension and Life Group Assurance schemes in operation, and housing assistance given if necessary.

Please write in confidence, giving age, full details of experience and salary required.—BOX No. E7120, "The Engineer." A

TECHNICAL SALES ENGINEER.—A vacancy exists in the Middlesex office of Twiflex Couplings, Ltd., for an Engineer of H.N.C. standard, to handle technical correspondence in the mechanical power transmission field. Some commercial experience is desirable but the main essential is a broad general engineering background with some knowledge of power transmission problems. The post is pensionable and provides excellent prospects for a young man to broaden his technical sales experience. —Write, stating age, experience and salary required, to Personnel Manager, The Green, Twickenham, Middlesex. E7081 A

SENIOR STRUCTURAL DESIGNER OR ARCHITECTURAL DRAUGHTSMAN with experience in reinforced concrete design, required for plant installations, industrial buildings and offices. Salary over £9000, according to experience. Interviews arranged to suit applicant.—Write or telephone to Chief Draughtsman, General Engineering Department, Northern Aluminium Company Limited, Rogerstone, Mon. (telephone, Newport 59991/6). E6812 A

SHIFT ENGINEER wanted for oil pumping station on the National Iranian Oil Co. staff in Iran. One year tours because married accommodation not immediately available. Salary £2100 tax free, plus free accommodation. Age 35/40. Diesel experience essential, oil pumping experience an advantage.—Write fullest particulars to Staff Officer,

Rendel, Palmer and Tritton, Consulting Engineers,

125, Victoria Street, London, S.W.1.

E6989 A

TECHNICAL SALES SERVICE MANAGER

required immediately by an expanding company in the Steel Equipment Industry. Applicants should have had experience in the sheet metal industry, be capable of controlling staff and have a thorough knowledge of Estimating. Experience of costing procedures and process planning an advantage. The appointment carries a four-figure salary and a pension scheme is in force. Only those giving full details of experience, age, salaries earned, &c., will be considered. Write to Sales Director.—BOX No. E1857, "The Engineer." A

THE SERVICES OF AN ASSISTANT ENGINEER are required in connection with Oil Refinery Maintenance. His immediate duties will relate to Inspection and Preventive Maintenance; applicants should therefore have had experience of this work in chemical works or refineries. The commencing salary will be £1000 to £1250, depending upon experience and qualifications. The successful applicant must be a Corporate Member of a professional Engineering Institution.—Applications should be addressed to the Refinery Manager, Lobitos Oilfields Limited, Ellesmere Port, Cheshire. E1851 A

TOOLROOM SUPERVISOR REQUIRED, man with good practical experience and able to control labour. Previous position in similar capacity essential. Write, giving particulars of past experience. —BOX No. E1821, "The Engineer." A

TRANSFORMER DESIGN.—An error occurred in the issue of May 2 in the advertisement headed CANADA. The last paragraph should have read: Both positions carry excellent salaries (over £200 per month) and substantial fringe benefits, paid passage, &c. E1859 A

TRANSLATORS accustomed to handling difficult German texts, are invited to contact Brunton Technical Translations, Charlotten-Str., 47, Dusseldorf, Germany. Must be able to write good English. Please state subjects handled and fees required. E6854 A

WEST MIDDLESEX FIRM have vacancy in Light Engineering Section for male ASSISTANT for Progress Control, Material Schedules, Requisitioning, Records, &c. Interesting prototype and development work. Write, stating age, previous experience, salary required.—BOX No. E1813, "The Engineer." A

WEST MIDDLESEX FIRM require keen and energetic young man for work on manufacture of variety of articles in reinforced fibre glass. Previous experience an advantage but not essential. Write.—BOX No. E1814, "The Engineer." A

WORKS MANAGER required by large firm of Civil Engineering Contractors, to supervise plant repair organisation, with modern workshops and equipment in South London. Top salary will be paid to a first-class Engineer, preferably qualified. Permanent and progressive position, with pension scheme. Reply, giving full details of experience.—BOX No. E1849, "The Engineer." A

YOUNG MEN, aged up to 28 years, required for training as ROLLING MILL SHIFT MANAGERS in large Midlands steelworks. This is a job offering excellent prospects to those selected and a good starting salary will be paid. Staff position, pension and free life assurance schemes in operation. Full details of age, experience and qualifications.—BOX No. E7121, "The Engineer." A

SMITHS OF ENGLAND
(MOTOR ACCESSORIES DIVISION)

SENIOR MECHANICAL and ELECTRICAL ENGINEERS

We need, in our Development Departments, Senior Mechanical and Electrical Engineers for work on instruments and mechanisms.

Applicants should be suitably qualified, will probably have served an apprenticeship and progressed through workshop and Drawing Office to development work associated with mechanical or electro-mechanical mechanisms.

Excellent working conditions with a four figure salary make employment with this Company an attractive proposition.

If you are interested and suitably qualified, write in confidence with details of age, experience and present salary to:

The Staff Manager, S. Smith & Sons (England), Ltd., Cricklewood Works, LONDON, N.W.2, quoting ref. SM/107.

E7065 A

MSL have been retained to advise on the appointment of a

CHIEF ENGINEER

for a company with over a hundred years' tradition of quality and skill in the design, manufacture and erection of the heavier type of cranes and auxiliary equipment both for the home and export markets. The company employs approximately 500 and is situated in a pleasant part of the North of England.

The appointment carries responsibility to the Managing Director for all engineering design and development, with customer contact and will entail occasional visits overseas.

Candidates must have extensive design experience in heavy engineering with a knowledge of modern welding techniques, and possess professional qualifications, preferably a degree, in mechanical and structural engineering. A wide general knowledge of industry and a commercial outlook is essential.

Preferred age 35-45. Salary £2,000—£3,000. The company operates an attractive pension scheme.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.968, to M. B. Berks.

MANAGEMENT SELECTION LIMITED

17, Stratton Street, London, W.1.

E7055 A

THE NUCLEAR POWER PLANT COMPANY LIMITED

require

SENIOR MECHANICAL DRAUGHTSMEN

with experience in any of the following:—

1. Layout of turbo-alternator and ancillary plant.
2. H.P. pipework layouts.
3. Pressure vessel design.
4. Chemical Plant design.

The Company operate a contributory pension scheme and assistance with house purchase is given to married men.

Written application, giving details of age, qualifications and career, should be sent to:—

The Secretary,
The Nuclear Power Plant Co., Ltd.,
Booths Hall,
Knutsford,
Cheshire.
Quoting reference TEG/MECH/43.

E7104 A

SITUATIONS VACANT

MACHINE SHOP SUPERINTENDENT

Pollard Bearings (Northampton), Ltd., require the services of a first-class Machine Shop Superintendent. Applications will be of particular interest from Engineers who have had a number of years' experience in the control of labour for quantity production on general or special machine tools.—Please state full details, together with age, salary expected, to General Manager, Pollard Bearings, Ltd., Ferrybridge, Yorks.

E7106 A

DEVELOPMENT ENGINEERS

are required by Girling, Limited, to deal with the increasing programme of development of new and established products.

DEVELOPMENT ENGINEERS — with degree or H.N.C., to take responsibility for the development of a range of products.

ASSISTANT DEVELOPMENT ENGINEERS—with H.N.C. and some development experience.

TECHNICAL ASSISTANTS (age 21-28 years) with O.N.C. and an interest in development work.

Salaries will be determined by qualifications and experience and will range from £800 p.a. for Assistant Development Engineers and from £950 p.a. for Development Engineers.

Apply in writing giving all relevant details of qualifications and background to the Personnel Manager, Girling, Limited, Kings Road, Tyseley, Birmingham, 11.

E7073 A

SITUATIONS VACANT

SENIOR DRAUGHTSMEN, DESIGN ENGINEERS

and

DESIGN DRAUGHTSMEN

At our Corby Works, one of the largest integrated Iron, Steel and Steel Tube Works in Europe, we have vacancies for MECHANICAL, ELECTRICAL, CIVIL and STRUCTURAL DRAUGHTSMEN.

The vacancies exist in the New Development Drawing-Offices and the Works Drawing-Offices. The work is interesting and offers scope and opportunity to talented young men.

Applicants with Higher National Certificate and experience in either the Iron and Steel industry or heavy engineering are preferred, but men with Ordinary level and relevant experience, or even unqualified men whose experience is outstanding, would be considered.

In addition to these vacancies, there are openings in other Drawing-Offices elsewhere in the Company.

Five-day week. Good welfare, canteen and recreation facilities. Superannuation and life assurance scheme. Staff hostel for single men. Favourable local housing conditions.

GOOD SALARIES BASED ON EXPERIENCE AND QUALIFICATIONS.

Applications will be treated as confidential and should be made, giving details of age, qualifications, experience, and salary required, to :

Manager/Personnel,
STEWARTS AND LLOYDS, LIMITED,
CORBY, Northants.

E11 A

SITUATIONS VACANT

SENIOR

DRAWING OFFICE CHECKER

Required by light engineering Company in North West London. The man appointed will be responsible for checking drawings prior to large scale production. Experience in this type of work is essential, preferably in the light precision engineering field. H.N.C. Standard or equivalent qualifications. Four figure salary and a progressive position offered.

Write, stating full particulars, to Box 2F Q1625, A.K. Advg., 212a, Shaftesbury Ave., London, W.C.2.

E7066 A

THE METAL BOX COMPANY LTD

manufacturers of all forms of metal, plastic and paper packages, requires

SALESMEN

for its conveyors, mechanical equipment and general engineering services. Candidates must have a good general engineering background and knowledge of the industries in which the sale of these services can be expanded. Appointments based on either London, the Midlands, or North West Lancashire.

Applications, in strict confidence, to Head of Staff Division,

METAL BOX,
37, BAKER ST., LONDON, W.1,
quoting reference SAR/1. E7064 A

JOSEPH LUCAS (ELECTRICAL) LIMITED

YOUNG ELECTRICAL AND MECHANICAL ENGINEERS

of Higher National Certificate standard, who are concerned with regard to their future prospects, are invited to apply for positions of Assistant Development Engineers in our development laboratories. The work covers a wide range of problems on new and interesting developments and the positions provide excellent opportunities for advancement. It is desirable that applicants should have served an apprenticeship and have had some previous experience in the design or development of electrical or light mechanical products. The posts are permanent and pensionable. Apply in writing, stating age, qualifications and experience, to the :

PERSONNEL MANAGER, JOSEPH LUCAS (ELECTRICAL) LIMITED, GREAT KING STREET, BIRMINGHAM, 19

quoting reference PM/D/219. E13 A

SUPERINTENDENT ENGINEER

required for service in NIGERIA by old-established British concern, to supervise and control an expanding group of factories processing a primary product, with the attendant European and African engineering staff.

Good all-round practical mechanical engineering knowledge is essential, with particular experience of medium range diesel engines and hydraulics. Experience of the erection of light structural steelwork and foundations an advantage.

Fully furnished and equipped housing provided. Contributory pension scheme, providing for retirement from age 55. First-class passages. Tours of 20 months, followed by 4 months' leave on full pay. Allowance for servants.

SALARY by arrangement and will be substantial.

Age range preferred 40 to 45.

Applicants will be interviewed in U.K. at convenient times. Time will be allowed for the receipt of applications from overseas.

In first instance apply in full confidence, to BOX No. E6894, "The Engineer."

SHEEPBRIDGE ENGINEERING LIMITED

announce the following vacancies at

CHESTERFIELD & GLASGOW

CHESTERFIELD

SENIOR DESIGNERS REF. EQD (a)

with experience in any of the following : Bulk material handling, Structural steelwork, Haulages, Winches, Mining Equipment, Special Purpose Machinery.

ESTIMATOR REF. EQD (b)

for Welded Fabrications, Steelwork and Plating Work.

MATERIAL SCHEDULE CLERKS REF. EQD (c)

experienced in taking off quantities from drawings of fabrications, Steelwork and Platework.

GLASGOW

SENIOR DESIGNERS REF. EQD (d)

with experience as above.

Five-day week. Overtime. Superannuation Scheme.

Write in confidence, giving age, qualifications, experience and present salary, quoting the appropriate reference number to :

Personnel Manager,
Sheepbridge Engineering, Ltd.,
Chesterfield,

or telephone Chesterfield 5471 or Glasgow Central 8816 for preliminary interview when we can discuss the mutual advantages of your joining us.

E7122 A

SITUATIONS WANTED

ASSISTANT MANAGER, Structural and Plate Fabrication Shop (34), A.M.I.Mech.E., A.M.I. Prod.E. Steelworks background, practical and competent, seeks position with prospects.—BOX No. E1860, "The Engineer." B

ERECTION FOREMAN OR SUPERVISOR, seventeen years' experience in all types of erection of steelwork, machinery, conveyors, &c., fair but strong disciplinarian, sound knowledge erection tackle.—BOX No. E1863, "The Engineer." B

TECHNICAL DIRECTOR (39), chief maintenance engineer for 11 years, wishes to consider change as Chief Engineer, Engineer Manager, or similar, with process concern or consultant. A.M.I.Mech.E., A.M.B.I.M., G.I.Struct.E., M.I.Plant.E., M.F. Building, &c. Sound knowledge of planned maintenance of steam raising plant, A.C. and D.C. electrical generation and distribution, refrigeration, hoists, hydraulic machines, overhead cranes, drying ; also maintenance and installation of chemical plant, extensive experience in building construction, including general plant layout. Capable of working on own initiative and directing all trades in mechanical, electrical and civil engineering. Present salary £2600, but scope for future advancement for a man of energy and ability more important than initial salary.—BOX No. E1816, "The Engineer." B

SUB-CONTRACTING

CANADA

Company has Canadian subsidiary specialising in Cold Roll Forming and Light Metal Fabrication, anxious to expand its operations by the addition of other lines of manufacture.

Modern works, with ample capacity for expansion and with sales and distribution depots throughout the country.

This organisation is offered to U.K. manufacturers for the purpose of :—

(a) Manufacturing on behalf of the U.K. Principal and providing the necessary secretarial and storage services, the U.K. Principal supplying machinery on loan and the necessary sales staff which can be attached to the existing depots.
or (b) Manufacturing on a royalty basis.
or (c) Acting as Selling Agents on a Sole Agency basis.

A Director of the Holding Company is leaving for Canada on the 18th May and all proposals should be sent, if possible, to BOX No. A358, c/o Streets, 110, Old Broad Street, E.C.2., by this date. E7116 MW

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved.—Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E575 MW

JOHN DOWNTON FOUNDRY & ENG. CO. LTD.
have capacity available on
CAPSTAN, CENTRE LATHE, VERTICAL BORING, MILLING MACHINES, etc.
also
FOUNDRY for hand and machine moulding
NON-FERROUS CASTINGS
Chipka Street, Millwall,
LONDON, E.14. Tel : East 2461.
E6930 MW

KELLERING and Profile Milling in all metals. Send us your die blocks to copy from wood or plaster masters. Up to 5ft. by 8ft. max. size. We are die copiers to the trade.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Tel.: Knottingley 2743/4). E948 MW

PRECISION ENGINEERS.—Personal service for prototypes, small quantity machined parts and equipments. Design and development undertaken. A.I.D. Approved.—Bowyer, Smyth and Partners, Ltd., Vineyard Walk, Clerkenwell, E.C.1. ('Phone, TERminus 5113/4). F650 MW

The Specialist Foundry
with own machine shop
for
BLACKHEART MALLEABLE IRON CASTINGS
●
HEAT AND ABRASION RESISTING ALLOY CASTINGS
●
Manufacturers of the
'PULMAC' PULVERISING MILLS
FOLLSAIN-WYCLIFFE FOUNDRIES LTD.
LUTTERWORTH, Nr. RUGBY
Tel. 10, 60 & 152 E985 MW

FOR HIRE

LATTICE STEEL Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1 ('Phone, SLOane 5259). E112 K

Classified Advts. continued on page 126

PATENTS

THE PROPRIETOR of British Patent No. 725,191, entitled "INDEXING MECHANISM FOR MACHINE TOOLS," offers same for Licence or otherwise, to ensure practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, 14 E., Jackson Boulevard, Chicago 4, Illinois, U.S.A. E7000 H

THE PROPRIETOR of British Patent No. 705,948, entitled "RELEASABLE TORQUE TRANSMITTING APPARATUS," offers same for Licence or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, 14 E., Jackson Boulevard, Chicago 4, Illinois, U.S.A. E6999 H

BUSINESS OPPORTUNITIES

FINANCE AVAILABLE to established Companies for the Purchase and Sale of Plant, Machinery and Equipment.—Dealest Finance Limited, 30, Mackenzie Street, Slough, Bucks. E1831 O

INVENTOR OF RETRACTING UNDERCARRIAGE.
Car Trailer.
Hand or Hydraulic Operated.
Wishes Produce and Market for home and overseas.
Sealed Patent, June, 1957.
Prototype and Drawings.
Kirkham, 295, Wells Road, Bristol. E7078 O

BUSINESSES and PREMISES

CANADIAN TRADE. Control of £1 million plant in Western Canada making steel items for £100,000 credit facilities.—BOX No. E1853, "The Engineer." L

POOLE. Light industrial premises. Two well-built factories, office, storage and toilet accommodation, total 2,750 sq. ft. Main services, 3-phase power, etc. £6,500 freehold.—Rumsey & Rumsey, High Street, Poole, Dorset. E7094 L

AGENCIES

AGENTS wanted, with knowledge of Oil Firing, for Selling Pressure Jet Oil Burners of well-known Swedish make and proved efficiency. Wide range from small domestic to light industrial. Quote Reference HEC.—BOX No. E1850, "The Engineer." D

COMMISSION IS OFFERED which can be quite substantial and permanent for the introduction to users of export cases, home trade cases, or any type of wood containers.—Contact BOX No. E1819, "The Engineer." D

ENGINEERS' AGENT, covering South West Lancashire, requires further lines in the Engineering Trade.—BOX No. E1854, "The Engineer." D

MANUFACTURER'S AGENT required, to represent file-making concern, one calling on large tool users preferred. Please state area able to cover. —BOX No. E7068, "The Engineer." D

MANUFACTURERS seeking to increase their sales in Scotland may secure reliable agents by writing with particulars to the Secretaries of the Scottish Association of Manufacturers' Agents who will advertise under a box number, in the Association News Letter.—Write to Dept. E., Hourston MacFarlane and Co., 5, St. Vincent Place, Glasgow, C.1. E962 D

MISCELLANEOUS

TIME RECORDERS, Sales, Rentals, Service, Telephone Hop 2239.—Time Recorder Supply and Maintenance Co., Ltd., 157–159, Borough High Street, London, S.E.1. E608 I

DRAWING & DESIGN SERVICE

FYNLINE PROJECTS, LTD.
Offer a Service for Detailing, Designing and Stressing in the Medium, Light, and Precision Fields of Mechanical Engineering.
All inquiries should be sent to :
61, BRUSHFIELD STREET,
LONDON, E.1.
E1818 S

MACHINERY Etc. WANTED

WANTED, Machines of all Types.
CASH PAID.
Norman E. Potts (B'ham), Ltd., 130, Moseley Road, Birmingham, 12. VIC. 1278, 1279, 1270, 0856. E123 F

WANTED, Tube Expanding Machine, Tube Cleaning Machine, 6in. to 8in. Screwing Machine, with collapsible head.—Fred Watkins (Boilers), Ltd., Coleford, Glos. E997 F

WANTED.—5000kW. Condensing Steam Turbo-Alternator Set, 400 p.s.i. steam pressure, 750 deg. F temperature, alternator 3·3kV., 3 phase, 50 cycles. Reply.—BOX No. E7001, "The Engineer." F

600–1000kW. TURBO-ALTERNATOR SET, 160 p.s.i.g., 100 deg. Fah. superheat, 10 lb. back pressure, preferably 400 volts, 3-phase, 50 cycles.—BOX No. E9098, "The Engineer." F

FOR SALE

METROPOLITAN WATER BOARD

SALE OF STEAM PLANT

WALTON PUMPING STATION

The Board will in the near future have FOR SALE as workable plant the following :—
THREE SETS of HIGH-SPEED, VERTICAL, TRIPLE-EXPANSION ENGINES driving horizontal-spindle centrifugal pumps direct. The engines are complete with condensers and all auxiliaries and work at a steam pressure of 200 lb. per square inch, superheated 100 deg. Fah.
Each set is capable of pumping 26 million gallons of water per 24 hours against a head of 50ft.
The sets will be available for dismantling towards the end of 1960. The tenderer must provide in his offer for the complete dismantling and clearing of the plant.
The plant can be seen working at the Board's Walton pumping station, Hurst Road, Walton-on-Thames, Surrey, on application to the Chief Engineer at the offices of the Board (Room 235), where the official forms of Tender are also obtainable.
Tenders, enclosed in sealed envelopes addressed to the Clerk of the Board, must be delivered at the Offices of the Board (Room 122), New River Head, Rosebery Avenue, London, E.C.1, not later than 11 a.m. on Friday, 27th June, 1958.
The Board do not bind themselves to accept the highest or any Tender.
S. D. ASKEW,
E7058 Clerk of the Board.

SOAG

UNUSED
STIRK PLANER
"PIONEER"
8ft. × 3ft. 6in. × 3ft.
DOUBLE COLUMN PLANING MACHINE
All electric split-field drive with two tool heads on cross rail and one side head ; tool lifts ; cutting speeds up to 240 f.p.m.
MODERN MACHINE
IMMEDIATE DELIVERY
Full particulars from :—
SOAG MACHINE TOOLS, LTD.,
JUXON STREET, LAMBETH, LONDON, S.E.11
'Phone : RELiance 7201.
'Grams : Sotoolsag, London, S.E.11 E210 G

600
COMPRESSOR SETS
TWO 600 c.f.m. T.S.2, 2-stage BROOM and WADE, 100 p.s.i., on bed plate, direct coupled to Crompton Parkinson 120 h.p. auto-synch. motor, 400/3/50, 375 r.p.m., with control gear.
TWO 485 c.f.m. REAVELL V.C.6, 2-stage, 100 p.s.i., on bed plate, direct coupled to 100 h.p. Brook slipring motor, 480 r.p.m., 400/3/50, with control gear.
PUMPING SETS
SEVEN 400 g.p.m., 300ft. hd., Diesel-engine-driven Sets, by CROSSLEY/SULZER.
SIX 50 g.p.m., 600 p.s.i., Petrol-engine-driven Duplex Pumps, by DAWSON and DOWNEY/MORRIS.
TWO 2500 g.p.m., 100ft. hd., MATHER and PLATT, with 125 h.p. motor, 400/3/50.
GEORGE COHEN,
SONS AND CO. LTD.
WOOD LANE, LONDON, W.12.
Tel.: Shepherds Bush 2070.
E201 G

STEEL BRIDGE RAILS—NEW—EX STOCK
7 tons, 26 lb. per yard, 24/30ft.
12 tons, 40 lb. per yard, 20/28ft.
11 tons, 56 lb. per yard, 40ft.
TODD BROS. (St. Helens and Widnes), LTD., ST. HELENS.
'Phone : 6151. E7060 G

VARIABLE SPEED UNITS Available from Stock, suitable for fitting to bench or pillar drills. Speed greatly increased and reduced, ratio 11 : 1. 5in. dia. size. £10 10s. Will give 16 separate speeds, which can be changed in ½ second. This Unit replaces Stepped Vee Pulleys and gear trains. This is the drive for machine tools of the future.—Send for details to-day.
PHILIP DE HAVILLAND MACHINE CO., LTD.,
64–66, Grosvenor Street, Portsmouth. E1792 G

TWO NEARLY NEW 350/400kVA. Condensing Geared Steam Turbo Sets, 150/200 lb. pressure, stainless blading, self-contained condensers, 400 volts, 3 phase, 50 cycles, and control equipment. Stand-by sets never put into commission.—BOX No. E7095, "The Engineer." G

CROSSLEY ENGINES FOR SALE.—Two 50 h.p. ; One 140 h.p. ; One 20 h.p. Available during August ; best offer secures.—Transport Director, TUCKS OF BURSTON, DISS, NORFOLK. E1856 G

FOR SALE

600
STEAM TURBO-ALTERNATOR SETS
3000kW., 6600/3/50, MET.-VICK., Pass-out/Condensing Steam Turbo-Alternator Set, date 1948, designed for 340 p.s.i.g. initially, 600 deg. Fah. temperature ; also suitable for the following duties :

Output/kW.	Pass-out/lb./hour	Lb. Pressure
3000	60,000	40
1800	40,000	110
1800	40,000	

double Pass/out at 1000kW., fully condensing.
2500kW., 440/3/50, B.T.H., speed 3000 r.p.m., 250 p.s.i.g., 630 deg. F., steam consumption approx. 12·8 lb./kW./hr., with surface condenser, circulating pumps, &c. Also suitable for pass-out pressures varying between 18/35 p.s.i.
GEORGE COHEN,
SONS AND CO. LTD.
WOOD LANE, LONDON, W.12.
Tel. : Shepherds Bush 2070 ; and
STANNINGLEY, NR. LEEDS.
Tel. : Pudsey 2241. E200 G

ORMEROD 26in. STROKE SLOTTING MACHINE
Table 50in. by 50in., with long, cross and rotary feeds, with rapid traverses in all directions. Maximum diameter admitted 7ft. 2in. Maximum height 3ft. 6in.
F. J. EDWARDS LTD.,
359–361, EUSTON ROAD, LONDON, N.W.1.
EUSton 4681 and 3771. E7046 G

HYDRAULIC PRESSES
HYDRAULIC PUMPS
Hydraulic Accumulators, Valves, Fittings, New and Second-hand. Complete installations.
All kinds of Hydraulic Equipment in stock.
THOMPSON AND SON (MILLWALL), LTD.,
Cuba Street Millwall, London, E.14.
East 1844/5.
E629 G

TWO NEARLY NEW POWERFUL CRANES
90-ton Electric Travelling Goliath Crane, 106ft. span, 72ft. lift, all lattice steel construction, electrics 400 volts, 3-phase, 50 cycles. Tested by Lloyds to 150 tons.
35-ton Electric Portal Wharf Crane, built 1945 ; 35 tons at 60ft. fixed radius, 85ft. height of lift, rail gauge 40ft., admitting 3 lines of standard gauge track, electrics 440/3/50, with Ward-Leonard generator.
REED BROTHERS (ENGINEERING), LTD.,
Replant Works, Woolwich Industrial Estate,
London, S.E.18.
Telephone : Woolwich 7611/6.
E9099 G

METROPOLITAN-VICKERS 500 H.P. SLIP-RING ELECTRIC MOTOR, 196 r.p.m., 400/440/3/50 cycles, complete with control panel and reduction gearbox, giving a final speed of 8·1 r.p.m.
Motor and gearbox available separately if required.
JOHN CASHMORE, LTD.
Newport, Mon.
Tel. : Newport 66941 (6 lines).
E991 G

10-TON CAPACITY, 3 motor, cab controlled, Overhead Electric Travelling Crane by Herbert Morris, 45ft. 6in. span ; 500V. D.C., complete with Brand New Crab.
F. BURRILL & CO.,
235a, CATHEDRAL ROAD,
CARDIFF.
Tel.: 26100 E6925 G

NO. 23 COCHRAN BOILER, 105 lb. W/P, 6030/8050 lb. evaporation, with mountings and feed pump. 1942. Available delivery ex Birmingham Works.—Abelson and Co. (Eng.), Ltd., 60, Clapham Road, London, S.W.9 (RELiance 7081). E7004 G

250KVA & 125KVA BELLISS STEAM ALTERNATOR SETS, 415/3/50. Attractive price.—BOX No. E7057, "The Engineer." G

FOR IMMEDIATE DELIVERY.—ONE 1500kW. B.T.H./CURTIS Steam Turbo-Alternator Set, 3000/3300 volts, 3-phase, 50 cycles ; steam 215 p.s.i., complete with condensing plant, circulating pumps, also switchgear. First-class condition.—BOX No. E7054, "The Engineer." G

UNUSED SET OF PLATE BENDING ROLLS, capacity 32ft. by 1in. down to 6ft. by 2½in. mild steel plate ; 75 h.p. roll drive, 40 h.p. screw-down ; electrics 400/3/50.—BOX No. E7096, "The Engineer." G

FOR SALE

TWIN

NEW 494 c.f.m. BELT-DRIVEN, THREE-CYLINDER, WATER-COOLED AIR COMPRESSOR, by BROOM and WADE, cyls. 10in. dia. × 12in. stroke, 120 h.p. slipring motor and starter, 400/440/3/50, EH–251.
NEW 300 c.f.m. MOTOR-DRIVEN, TWIN-CYLINDER, WATER-COOLED AIR COMPRESSOR, cyls. 10in. dia. × 12in. stroke, 70 h.p. S.R. motor and starter, 400/440/3/50.
240 c.f.m. MOTOR-DRIVEN, SINGLE-STAGE, DOUBLE-ACTING AIR COMPRESSOR, type S.1, cylinders 12in. bore × 7in. stroke, driven through vee belts from 35 h.p., slipring motor and starter, suitable for 400/440/3/50 cycles, BROOM and WADE.
150 c.f.m. TWIN-CYLINDER, WATER-COOLED AIR COMPRESSOR, type D22A, cyls. 7½in. dia. × 8in. stroke, 35 h.p., S.R. motor and starter, 400/440/3/50.
THOS. W. WARD LTD.
ALBION WORKS - - - SHEFFIELD.
'Phone : 26311. 'Grams : "Forward."
E213 G

ABELSON offer the following equipment for immediate delivery :—
Smith 5-ton capacity Rail-mounted Steam Loco. Crane. New 1951.
Fully reconditioned Fowler 150 H.P. 0-4-0 Diesel Locomotive.
First-class Barclay 0-4-0 84 H.P. Diesel Locomotive.
First-class Ruston 0-4-0, 48 H.P., Diesel Shunting Loco.
All the above machines suitable for 4ft. 8½in. gauge.
For further details contact :
ABELSON AND CO. (ENGINEERS), LTD., COVENTRY ROAD, SHELDON, BIRMINGHAM, 26.
Tel.: SHEldon 2424.
E7005 G

NISSEN TYPE HUTS for sale. Prompt despatch of 16ft., 24ft. and 30ft. wide huts ; also "Romney" Huts, 35ft. wide, and "Blister" Hangars, 86ft. 6in. and 91ft. wide. These buildings are in various lengths and comprise steel framework with galvanised corrugated steel sheeting.—Full details from Dept. 115, J. Thorn and Sons, Ltd., Brampton Road, Bexleyheath, Kent (Tel., Bexleyheath 305). E681 G

THE 600 GROUP OF COMPANIES
RECONDITIONED
JONES CRANES
with 3 Months' Guarantee

KL.44	Capacity	4 tons
KL.40	,,	3 tons
KL.22	,,	2 tons
KL.15	,,	15 cwts

All Jones Cranes receive 12 months' free after-sales service when supplied by :—
GEORGE COHEN
Sons and Company Limited
WOOD LANE LONDON, W.12
Telephone : SHEPHERDS BUSH 2070
E7409 G

RUNNING SHORT?
REMEMBER...
WARDS might have it!
THOS. W. WARD LTD
ALBION WORKS, SHEFFIELD

FOR SALE

SERVICE EDWARDS VALUE!

AEROGRAPH Air Compressor Unit, comprising type D13, single cylinder, vertical, water cooled air compressor, with automatically operated valves and forced lubrication from direct-driven valveless, plunger type, oil pump ; air governor, capacity 40 cu. feet per minute, 100 lb. per square inch pressure, bore by stroke 6in. by 7in., speed 420 r.p.m., arranged motor drive 400/440/3/50.

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		Main Location	*Auctioneers*
May 12–16	**Vehicles, lifting equipment, trailers, motor cycles, etc.**	M.O.S. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
May 15	**Miscellaneous stores,** including furniture, hand tools, etc.	General Stores Sub-Depot, **Longtown, Nr. Carlisle.** (Sale at County Hall, Carlisle.)	**HARRISON & HETHERINGTON, LTD.** (Dept. L), Botchergate, Carlisle. (Tel.: 26292/3.)
May 22	**Miscellaneous stores,** including engines, ball bearings, etc.	M.O.S. Storage Depot, **Rotherwas, Hereford**	**RUSSELL, BALDWIN & BRIGHT, LTD.** (Dept. L), 20, King Street, Hereford. (Tel.: 4366.)
May 29–30	**Miscellaneous builders', plumbers' and electric equipment,** including :— Drainage pipes, channels and fittings, rainwater goods, steel piling, steel shores, panels and pins, galvanised tanks, cisterns, asbestos sheeting and roofing, timber, glass, paints, expanded metal sheets, copper and brass tape, valves, pipes, sinks, lavatory basins, meters, fuses, wire, electric cookers and rings, thermostats, voltmeters, washboilers, shades and fans, 8 h.p. outboard motors, pontoons, etc.	No. 1 Engineer Stores Depot, **Long Marston, Nr. Stratford on Avon, Warwickshire.**	**LOCKE & ENGLAND** (Dept. L), 166, Parade, Leamington Spa. (Tel.: 2833.)
June 3	**Machine tools, cranes and miscellaneous stores,** including furniture, etc.	M.O.S. Sub Depot, **Lily Lane, Byley, Middlewich, Cheshire.** (Sale at New Islington Public Hall, Ancoats, Manchester.)	**J. H. NORRIS & SON** (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
June 6	**Miscellaneous stores.**	Returned Stores Depot, **Reed Hall, Colchester, Essex**	**FENN, WRIGHT & CO.** (Dept. L), 146, High Street, Colchester, Essex. (Tel.: 3171.)
June 9–12	**Vehicles, machine tools, miscellaneous stores,** including clothing, etc.	M.O.S. Storage Depot, **Royal Arsenal, Woolwich, London, S.E.18.**	**FULLER, HORSEY, SONS & CASSELL** (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)

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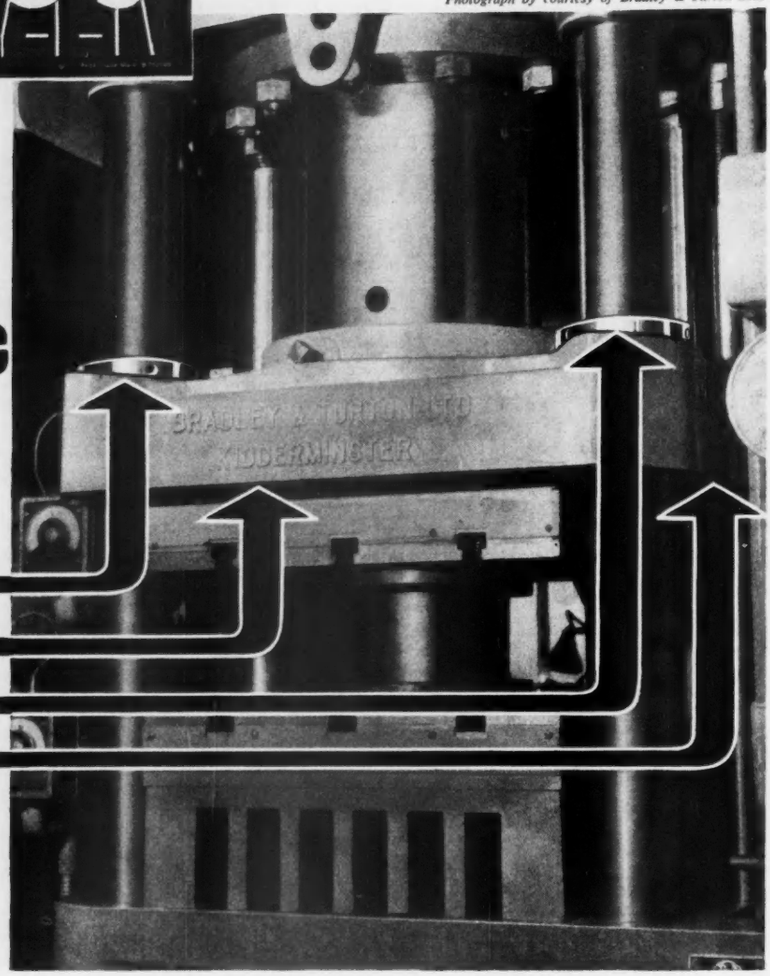

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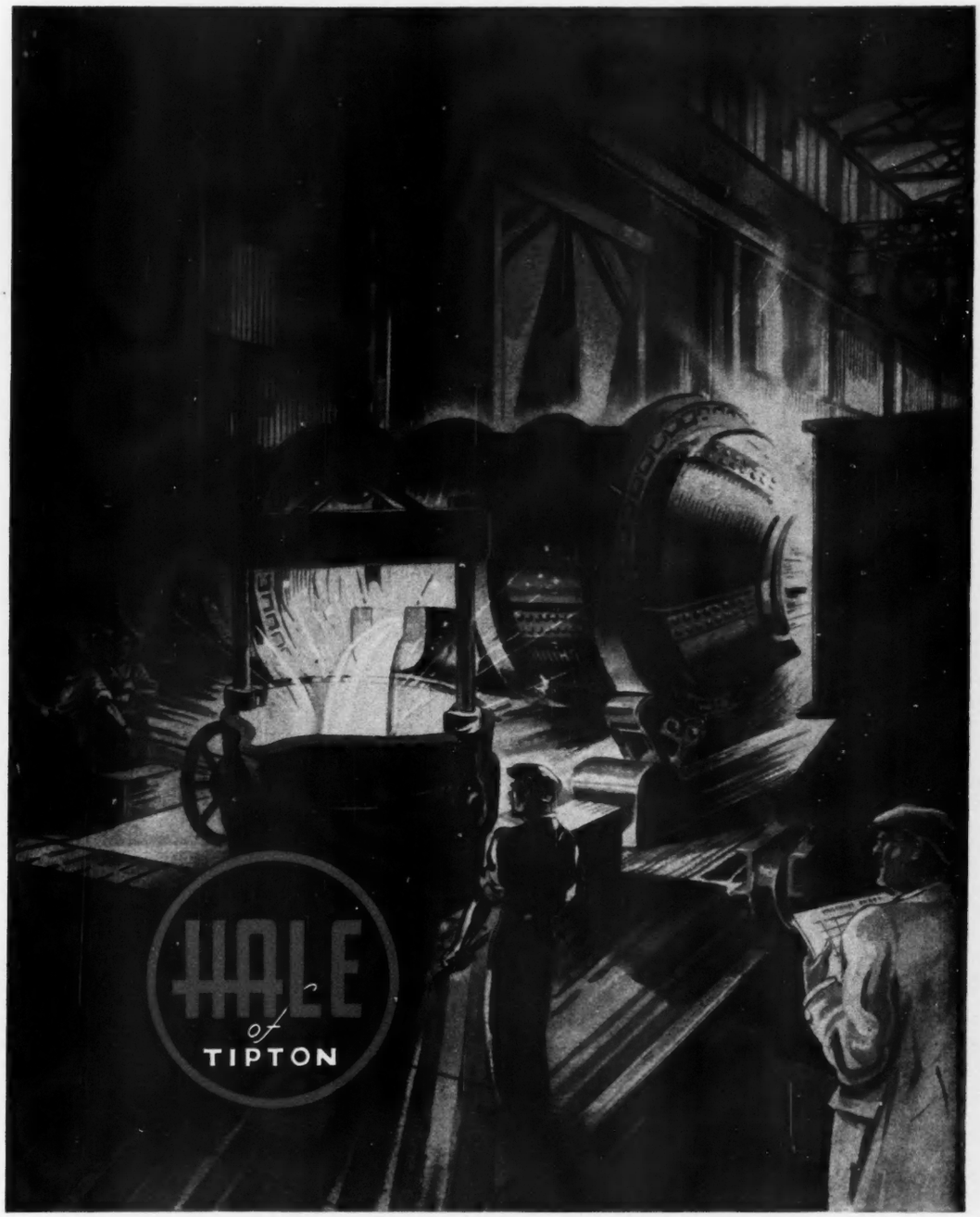

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